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Electromagnetic compatibility (EMC) -
Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with ~~input~~ mains current more than 16 A per phase

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Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with ~~input~~ mains current more than 16 A per phase

FOREWORD

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This consolidated version of the official IEC Standard and its amendments has been prepared for user convenience.

IEC 61000-4-34 edition 1.2 contains the first edition (2005-10) [documents 77A/498/FDIS and 77A/515/RVD], its amendment 1 (2009-05) [documents 77A/670/CDV and 77A/688/RVC] and its corrigendum 1 (2009-10), and its amendment 2 (2025-08) [documents 77A/1233/CDV and 77A/1247/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 61000-4-34 has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms Part 4-34 of IEC 61000. It has the status of a Basic EMC Publication in accordance with IEC Guide 107.

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

FDIS	Report on voting
77A/498/FDIS	77A/515/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 document and its amendments 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- withdrawn, or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 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).

INTRODUCTION to Amendment 2

This amendment contains the following main changes in comparison with IEC 61000-4-34:2005 and IEC 61000-4-34:2005/AMD1:2009:

- Addition of a note in Annex C: The sign of phase angles of three-phase systems can differ depending on the convention used. It should be noted that phase angles opposite to those used in the figures and tables in this annex (i.e. -120° for L2 instead of +120°) are also common. It is not intended to specify the direction of rotation of the three-phase system used for testing.
- Add UL1-N = √(1+3P^2)/2 in Annex C.3,
- Add a new annex "Interpretation of the rise-time and fall-time requirements during EUT testing" (Annex F), as in IEC 61000-4-11:2020, Clause D.4:

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~~ mains current exceeding 16 A per phase. (See Annex E for guidance on electrical and electronic equipment rated at more than 200 A per phase.) It covers equipment installed in residential areas as well as industrial machinery, specifically voltage dips and short interruptions for equipment connected to either 50 Hz or 60 Hz a.c. networks, including 1-phase and 3-phase mains.

NOTE 1 Equipment with a rated ~~input~~ mains current of 16 A or less per phase is covered by publication IEC 61000-4-11.

NOTE 2 There is no upper limit on rated ~~input~~ mains current in this publication. However, in some countries, the rated ~~input~~ mains current may be limited to some upper value, for example 75 A or 250 A, because of mandatory safety standards.

It does not apply to electrical and electronic equipment for connection to 400 Hz a.c. networks. Tests for equipment connected to 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 1 Voltage fluctuations are covered by publication IEC 61000-4-14.

NOTE 2 For equipment under test with rated currents above 250 A, suitable test equipment may be difficult to obtain. In these cases, the applicability of this standard should be carefully evaluated by committees responsible for generic, product and product-family standards. Alternatively, this standard might be used as a framework for an agreement on performance criteria between the manufacturer and the purchaser.

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

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*

IEC 61000-4-30, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161 as well as the following definitions apply:

3.1

basic EMC standard (ACEC)[1]
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

3.2

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]

3.3

voltage dip
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
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 operation related to the occurrence and termination of short circuits on the system or installations connected to it.

3.5

residual voltage (of voltage dip)
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~~

~~**rated input voltage**~~
~~U_T~~
~~root-mean-square input supply voltage for which the equipment has been designed. Several rated input voltages may be specified for one equipment~~

~~3.7~~3.6

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

~~3.8~~3.7

calibration
set of operations which establishes, by reference to standards, the relationship which exists, under specified conditions, between an indication and a result of a measurement

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[1] Advisory Committee on Electromagnetic Compatibility (ACEC).

NOTE 1 This term is based on the "uncertainty" approach.

NOTE 2 The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

[IEV 311-01-09]

~~3.9~~3.8
verification
set of operations which is used to check the test equipment system (e.g. the test generator and the interconnecting cables) and 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 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 so that the intended waveform is delivered to the EUT.

NOTE 3 For the purpose of this basic EMC standard this definition is different from the definition given in IEV 311-01-13.

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.

Voltage dips at equipment terminals are influenced by the transformer connections between the fault location on the supply system and the equipment connection point. The transformer connections will influence both the magnitude and the phase relationship of the voltage dip experienced by the equipment.

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 (U_T).

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;
- the selection of test levels and durations shall take into account the information given in IEC 61000-2-8.

5.1 Voltage dips and short interruptions

The change between U_T and the changed voltage is abrupt. Unless otherwise specified by the responsible product committee, the start and stop phase angle for the voltage dips and interruptions shall be 0° (i.e. the positive-going voltage zero-crossing on the dipped phase), See 8.2.1. The following test voltage levels (in % U_T) are used: 0 %, 40 %, 70 % and 80 %, corresponding to voltage dips or interruptions 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 1.

For short interruptions, the preferred test levels and durations are given in Table 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 test levels, for example 0 % test level for 1 s, and balanced three-phase dips, may be considered by product committees.

The voltage rise time, t_r, and voltage fall time, t_f, during abrupt changes are indicated in Table 4. Furthermore, additional information is given in Annex F with respect to the correct interpretation of rise-time and fall-time requirements during EUT testing.

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 an 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

Classes[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 % [d] 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 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", “10/12 cycles” means “10 cycles for 50 Hz test” and “12 cycles for 60 Hz test” and “250/300 cycles” means “250 cycles for 50 Hz test” and “300 cycles for 60 Hz test”.

[d] May be replaced by product committee with a test level of 50 % for equipment that is intended primarily for 200 V or 208 V nominal operation.

Table 2 – Preferred test level and durations for short interruptions

Classes[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 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.

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 voltages 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 rate 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_i) (50 Hz/60 Hz)**
70 %	Abrupt	1 cycle	25/30[b] cycles
X[a]	X[a]	X[a]	X[a]

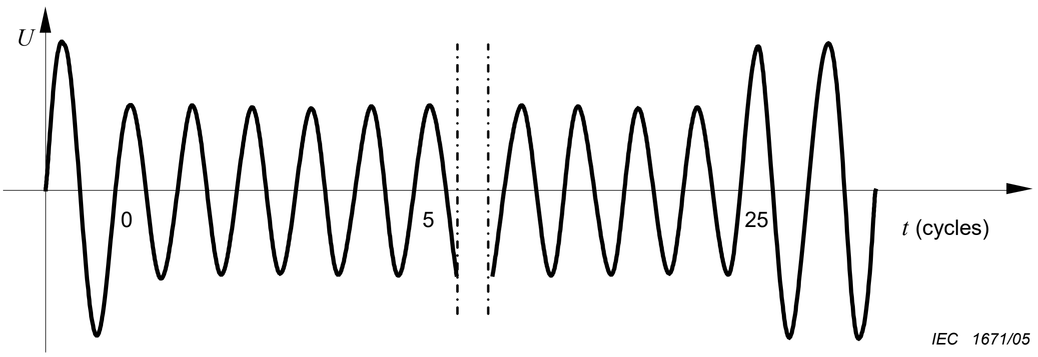
[a] To be defined by product committee.

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

For voltage variations in three-phase systems with or without neutral, all the three phases shall be tested simultaneously. Simultaneous voltage variations in three-phase systems are positioned at the zero-crossing of one of the voltages.

This shape is the typical shape of a motor starting with a rapid time for decreasing voltage, t_d, and slower time for increasing voltage, t_i.

Figure 2 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 cycles (50 Hz). Step at zero crossing.

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

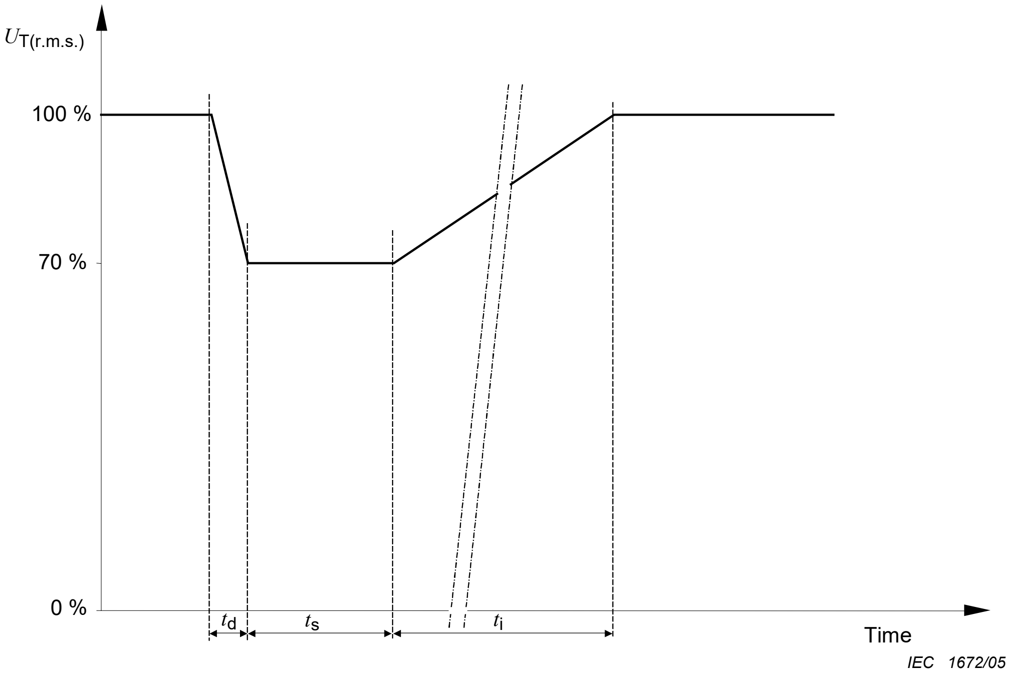


Figure 2 – Voltage variation

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 D.

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.

The output of the generator may be influenced by the generator characteristics, the load characteristics, and/or the characteristics of the a.c. network that supplies the generator.

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 at the output of the generator during equipment test	As required in Table 1, ±10 % of residual voltage value, measured as r.m.s. value refreshed each ½ cycle per IEC 61000-4-30
Output current capability	See Annex A
Peak inrush current capability (no requirement for voltage variation tests)	See Annex A
Instantaneous peak overshoot/undershoot of the actual voltage, generator loaded with resistive load – see NOTE 1	Less than 5 % of U_T
Voltage rise (and fall) time t_r (and t_f), during abrupt change, generator loaded with resistive load – see NOTE A and NOTE 1	Between 1 μs and 5 μs for current ≤75 A Between 1 μs and 50 μs for current >75 A
Phase angle at which the voltage dip begins and ends	0° to 360° with a maximum resolution of 5°, see NOTE B
Phase relationship of voltage dips and interruptions with the power frequency	Less than ±5°
Zero crossing control of the generators	±10°

NOTE A These values must be checked with a resistive load as per NOTE 1 after this table, but they need not be checked when an EUT is connected.

NOTE B Phase angle adjustment may be required to comply with 5.1.

Output impedance shall be predominantly resistive.

The output impedance of the test voltage generator shall be low even during transitions when generating dips. A brief interval (up to 100 µs) of high impedance is permitted during each transition. For generating interruptions, a high impedance open circuit is ~~preferred~~ permited.

NOTE 1 The value of the non-inductive resistive load for testing overshoot, undershoot, rise time, and fall time shall be 100 ohms for generators rated for 50 A or less, 50 ohms for generators rated for more than 50 A and less or equal than 100 A, and 25 ohms for generators rated more than 100 A.

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

NOTE 3 A high-impedance interruption, when applied to an inductive load, may generate substantial over-voltages.

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 the specified percentage of the U_T;
- the voltage at the output of the generator shall be monitored during tests as an r.m.s. value refreshed each ½ cycle, and shall be maintained within the specified percentage throughout the tests.

NOTE If it can be demonstrated that the equipment peak current requirements are sufficiently small as not to influence the voltage at the output of the generator, it is not necessary to monitor the output voltage during tests.

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 315° 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°.

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.

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 (optional).

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

8 Test procedures

Caution should be exercised during the set-up and execution of these tests. EUT and test equipment shall not become dangerous or unsafe as a result of the application of the tests defined in this part of IEC 61000. Precautions should be taken to avoid dangerous and unsafe situations for personnel, the EUT, and the test equipment.

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 intended to be 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;
- information about the inrush current requirements of the equipment;
- 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.

8.1 Laboratory reference conditions

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 be such as to guarantee the correct operation of the EUT in order not to influence the test results.

8.2 Execution of the test

During the tests, the mains voltage for testing shall be monitored within an accuracy of 2 %.

8.2.1 Voltage dips and short interruptions

The EUT shall be tested for each selected combination of test level and duration with a sequence of three dips/interruptions with intervals of 10 s minimum (between each test event). Each representative mode of operation shall be tested.

For voltage dips, changes in supply voltage shall occur at 0° (positive-going zero crossing of the voltage)~~, except for ½ cycle test which shall occur at 90°~~. Additional angles considered critical may be selected by product committees or individual product specifications preferably from 45°, 90°, 135°, 180°, 225°, 270° and 315° on each phase.

~~NOTE Because of saturation effects of inductive loads such as transformers and motors (which tend to be more significant in equipment rated for greater than 16 A per phase), dips with a half-period duration that commence at 0° or 180° should be avoided.~~

For short interruptions, the starting angle shall be defined by the product committee as the worst case. In the absence of definition, it is recommended to use 0° for one of the phases.

For short interruptions test of three-phase systems, all the three phases shall be simultaneously tested as per 5.1.

For voltage dips test of single-phase systems, the voltage shall be tested as per 5.1. This implies one series of tests.

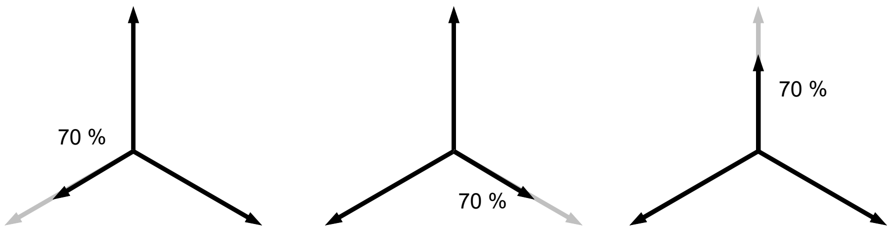
For voltage dips test of three-phase systems with neutral, each individual voltage (phase-to-neutral and phase-to-phase) shall be tested, one at a time, as per 5.1. This implies six different series of tests. See Figure 3a, Figure 3b and Figure 3c~~, and Figure D.2.a and Figure D.2.b in Annex D~~.

For voltage dips test of three-phase systems without neutral, each phase-to-phase voltage shall be tested, one at a time, as per 5.1. This implies three different series of tests. See Annex C. See Figure 3b and Figure 3c~~, and Figure D.2.a in Annex D~~.

NOTE 1 For three-phase systems, during a dip on a phase-to-phase voltage, a change will occur on one or two of the other voltages as well.

NOTE 2 For phase-to-phase testing on three-phase systems, the vectors of Figure 3b represents Acceptable Method 1, and the vectors of Figure 3c represent Acceptable Method 2. The Acceptable Method 1 vectors shown in Figure 3b may be easier for test labs to generate. See Annex D, Figure D.1. The Acceptable Method 2 vectors shown in Figure 3c may be more representative of real-world dips. There may be significant differences between results when comparing the vectors of Figure 3b to the vectors of Figure 3c.

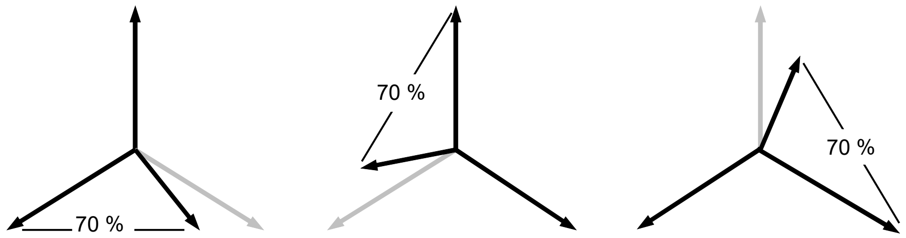
For EUTs with more than one power cord, each power cord should be tested individually.



IEC 1673/05

NOTE Phase-to-neutral testing on three-phase systems is performed one phase at a time.

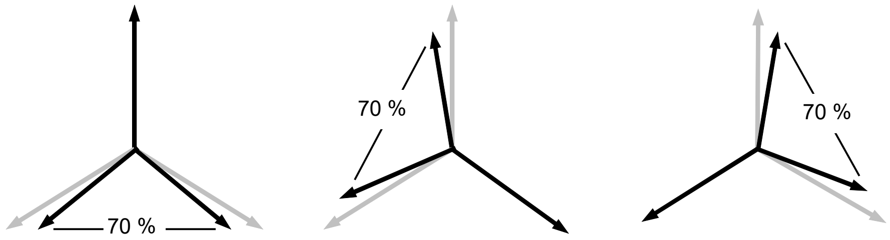
Figure 3a – Phase-to-neutral testing on three-phase systems



IEC 1674/05

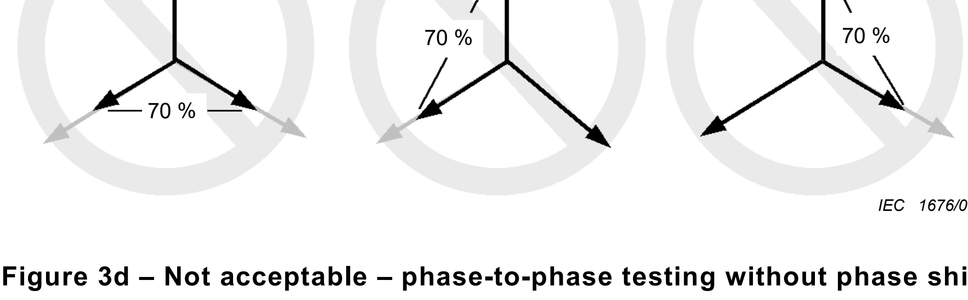
NOTE Phase-to-phase testing on three-phase systems is also performed one phase at a time

Figure 3b – Phase-to-phase testing on three-phase systems – Acceptable Method 1 phase shift



IEC 1675/05

Figure 3c – Phase-to-phase testing on three-phase systems – Acceptable Method 2 phase shift



IEC 1676/05

Figure 3d – Not acceptable – phase-to-phase testing without phase shift

Figure 3 – Testing on three-phase systems

8.2.2 Voltage variations (optional)

The EUT is tested to each of the specified voltage variations, three times at 10 s intervals for the most representative modes of operations.

9 Evaluation of test results

The test results shall be classified in terms of the loss of function or degradation of performance of the equipment under test, relative to a performance level defined by its manufacturer or the requestor of the test, or agreed between the manufacturer and the purchaser of the product. The recommended classification is as follows:

a) normal performance within limits specified by the manufacturer, requestor or purchaser;

b) temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention;

c) temporary loss of function or degradation of performance, the correction of which requires operator intervention;

d) loss of function or degradation of performance which is not recoverable, owing to damage to hardware or software, or loss of data.

The manufacturer's specification may define effects on the EUT which may be considered insignificant, and therefore acceptable.

This classification may be used as a guide in formulating performance criteria, by committees responsible for generic, product and product-family standards, or as a framework for the agreement on performance criteria between the manufacturer and the purchaser, for example where no suitable generic, product or product-family standard exists.

NOTE The performance levels may be different for voltage dip tests and short interruption tests as well as for voltage variations test, if this optional test has been required.

10 Test report

The test report shall contain all the information necessary to reproduce the test. In particular, the following shall be recorded:

- the items specified in the test plan required by Clause 8;
- identification of the EUT and any associated equipment, e.g. brand name, product type, serial number;
- identification of the test equipment, e.g. brand name, product type, serial number;
- any special environmental conditions in which the test was performed, for example shielded enclosure;
- any specific conditions necessary to enable the test to be performed;
- performance level defined by the manufacturer, requestor or purchaser;
- performance criterion specified in the generic, product or product-family standard;
- any effects on the EUT observed during or after the application of the test disturbance, and the duration for which these effects persist;
- the rationale for the pass/fail decision (based on the performance criterion specified in the generic, product or product-family standard, or agreed between the manufacturer and the purchaser);
- any specific conditions of use, for example cable length or type, shielding or grounding, or EUT operating conditions, which are required to achieve compliance.

Annex A

(normative)

Test generator ~~peak inrush~~ current drive capability

During voltage dip testing, equipment peak inrush current may greatly exceed equipment rated current. The peak inrush current may occur at any time during the equipment process, not necessarily when power is first applied to the equipment.

During voltage dip testing on polyphase loads, the current on non-dipped phases may increase to as much as 200 % of the rated current, for the duration of the dip.

~~Peak~~ Current capability at the output of a test generator may be a function of both the test generator and of the a.c. mains source that supplies power to the test generator.

A.1 Test generator inrush current requirement

The test generator shall be capable of supplying the peak inrush current shown in Table A.1.

Table A.1 – Minimum peak inrush current capability

Rated current of Equipment	Minimum peak inrush current capability of the generator
16 A – 50 A	500 A
50,1 A – 100 A	1 000 A
More than 100 A	Not less than 1 000 A, and sufficient to maintain ±10 % of required voltage value during maximum peak inrush, measured as r.m.s. value refreshed each ½ cycle per IEC 61000-4-30.

A.2 Measuring test generator peak inrush current drive capability

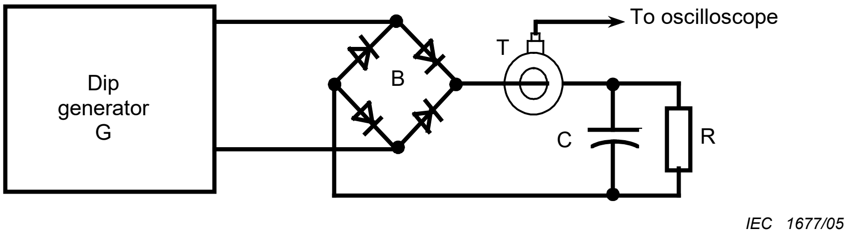
The circuit for measuring generator peak inrush current drive capability is shown in Figure A.1. Use of the bridge rectifier makes it unnecessary to change rectifier polarity for tests at 270° versus 90°.

The 1 700 µF electrolytic capacitor shall have a tolerance of ±20 %. It shall have a voltage rating preferably 15 % – 20 % in excess of the nominal peak voltage of the mains, for example 400 V for 220 V – 240 V mains. The capacitor shall have the lowest possible equivalent series resistance (ESR) at both 100 Hz and 20 kHz, and the peak inrush current shall not be limited by the capacitor ESR. Multiple capacitors may be paralleled to achieve sufficiently low ESR.

Since the test shall be performed with the 1 700 µF capacitor discharged, a resistor shall be connected in parallel with it and several time constants (RC) must be allowed between tests. With a 10 000 Ω resistor, the RC time constant is 17 s, so that a wait of 1,5 min to 2 min should be used between inrush drive capability tests. Resistors as low as 100 Ω may be used when shorter wait times are desired.

The current probe shall be able to accommodate the full generator peak inrush current drive for one-quarter cycle without saturation.

Tests shall be run by switching the generator output from 0 % to 100 % at both 90° and 270°, to ensure sufficient peak inrush current drive capability for both polarities.



Components

G	test voltage generator, switched on at 90° and 270°
T	current probe, with monitoring output to oscilloscope
B	rectifier bridge
R	bleeder resistor, not over 10 000 Ω or less than 100 Ω
C	1 700 μF ±20 % electrolytic capacitor

Figure A.1 – Circuit for determining inrush current drive capability

A.3 Test generator requirement during dip current

During dip tests on polyphase loads, the test generator shall be capable of supplying sufficient current on the non-dipped phase conductors, during the dip, to maintain the voltages required in Table 1, ±10 %, measured as r.m.s. value (average time 1 cycle) refreshed each ½ cycle as per IEC 61000-4-30.

NOTE During the dip, the current on the non-dipped phase conductors may be as much as 200 % of the rated current.

Annex B
(informative)

Electromagnetic environment classes

The following electromagnetic environment classes have been summarised from IEC 61000-2-4.

Class 1

This class applies to protected supplies and has compatibility levels lower than public network levels. It relates to the use of equipment very sensitive to disturbances in the power supply, for instance the instrumentation of technological laboratories, some automation and protection equipment, some computers, etc.

NOTE Class 1 environments normally contain equipment which requires protection by such apparatus as uninterruptible power supplies (UPS), filters, or surge suppressers.

Class 2

This class applies to points of common coupling (PCCs for consumer systems) and in-plant points of common coupling (IPCs) in the industrial environment in general. The compatibility levels in this class are identical to those of public networks; therefore components designed for application in public networks may be used in this class of industrial environment.

Class 3

This class applies only to IPCs in industrial environments. It has higher compatibility levels than those of class 2 for some disturbance phenomena. For instance, this class should be considered when any of the following conditions are met:

– a major part of the load is fed through converters;
– welding machines are present;
– large motors are frequently started;
– loads vary rapidly

NOTE 1 The supply to highly disturbing loads, such as arc-furnaces and large converters which are generally supplied from a segregated bus-bar, frequently has disturbance levels in excess of class 3 (harsh environment). In such special situations, the compatibility levels should be agreed upon.

NOTE 2 The class applicable for new plants and extensions of existing plants should relate to the type of equipment and process under consideration.

Annex C
(informative)

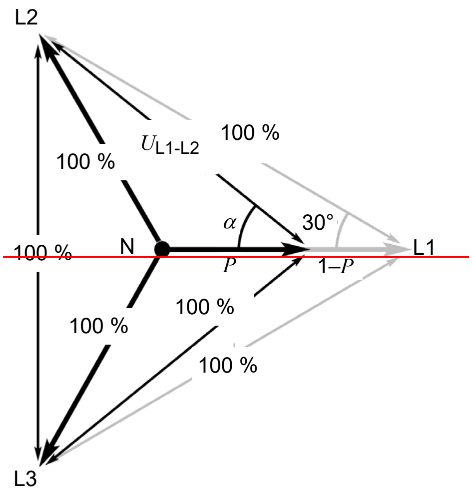
Vectors for three-phase testing

The graphs, equations, and tables in this annex all assume that the neutral conductor is electrically centered between the three phase conductors. For electrical systems in which the neutral is not electrically centered, different vectors must be created.

NOTE The phase angles of three-phase systems can differ depending on the convention used. It is noted that phase angles opposite to those used in the figures and tables in Annex C (i.e. -120° for L2 instead of +120°) are also common. It is not intended to specify the direction of rotation of the three-phase system used for testing.

C.1 Phase-to-neutral dip vectors

Voltage dips are applied phase-to-neutral, one phase at a time (see 8.2.1). The example dip generator in Fig. D.1 generates these vectors when applied as shown in Fig. D.2.b.



IEC 1678/05

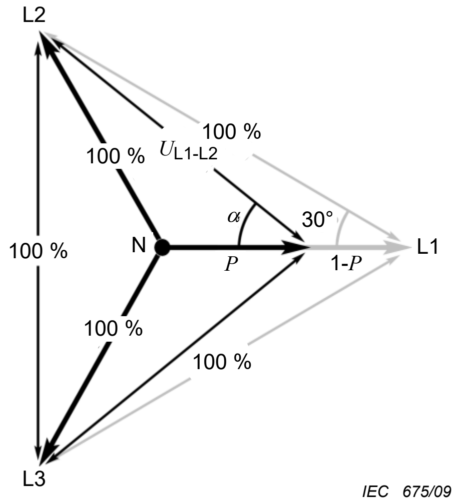
~~$\alpha = \sin^{-1}\left(\dfrac{\sin(120^0)}{\sqrt{1+P^2-2P\cos(120^0)}}\right)$ (C.1)~~

~~$U_{L1-L2} = \dfrac{\sqrt{1+P^2-2P\cos(120^0)}}{\sqrt{3}}$ (C.2)~~

~~***P*** is the percent phase-to-neutral dip, expressed as a fraction of the nominal phase-to-neutral voltage.~~

~~$U_{\text{L1-L2}}$ is the voltage from L1 to L2, expressed as a fraction of the nominal phase-to-phase voltage.~~

~~NOTE The $\sin^{-1}$ function is ambiguous (there are always two angles that have the same value), and returns values between -90° and +90°, so the correct quadrant must be selected.~~



IEC 675/09

$$\alpha = \sin^{-1}\left(\frac{\sin(120^\circ)}{\sqrt{1+P^2-2P\cos(120^\circ)}}\right) \qquad (C.1)$$

$$U_{\text{L1–L2}} = \frac{\sqrt{1+P^2-2P\cos(120^\circ)}}{\sqrt{3}} \qquad (C.2)$$

P is the percent phase-to-neutral dip, expressed as a fraction of the nominal phase-to-neutral voltage.

UL1-L2 is the voltage from L1 to L2, expressed as a fraction of the nominal phase-to-phase voltage.

NOTE The sin–1 function is ambiguous (there are always two angles that have the same value), and return values between –90° and +90°, so the correct quadrant must be selected.

Figure C.1 – Phase-to-neutral dip vectors

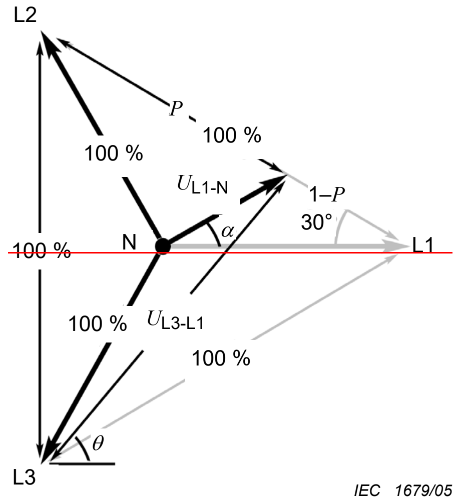
Table C.1 – Vector values for phase-to-neutral dips

P	$U_{L1\text{-}L2}$	$U_{L2\text{-}L3}$	$U_{L3\text{-}L1}$	$U_{L1\text{-}N}$	$U_{L2\text{-}N}$	$U_{L3\text{-}N}$
100 % (no dip)	100 % 150°	100 % 270°	100 % 30°	100 % 0°	100 % 120°	100 % 240°
80 % L1-N	90 % 146°	100 % 270°	90 % 34°	80 % 0°	100 % 120°	100 % 240°
80 % L2-N	90 % 154°	90 % 266°	100 % 30°	100 % 0°	80 % 120°	100 % 240°
80 % L3-N	100 % 150°	90 % 274°	90 % 26°	100 % 0°	100 % 120°	80 % 240°
70 % L1-N	85 % 144°	100 % 270°	85 % 36°	70 % 0°	100 % 120°	100 % 240°
70 % L2-N	85 % 156°	85 % 264°	100 % 30°	100 % 0°	70 % 120°	100 % 240°
70 % L3-N	100 % 150°	85 % 276°	85 % 24°	100 % 0°	100 % 120°	70 % 240°
40 % L1-N	72 % 136°	100 % 270°	72 % 44°	40 % 0°	100 % 120°	100 % 240°
40 % L2-N	72 % 164°	72 % 256°	100 % 30°	100 % 0°	40 % 120°	100 % 240°
40 % L3-N	100 % 150°	72 % 284°	72 % 16°	100 % 0°	100 % 120°	40 % 240°

NOTE “100 %” represents the voltage when no dip is present. For phase-to-phase voltages, this value will be higher than the 100 % phase-to-neutral value by a factor of $\sqrt{3}$.

C.2 Acceptable Method 1 – phase-to-phase dip vectors

On three-phase systems, voltage dips are applied phase-to-phase, one pair of phases at a time (see 8.2.1). The vectors shown in Figure C.2 represent Acceptable Method 1 for phase-to-phase dips on three-phase systems. The example dip generator in Fig. D.1 generates these vectors when applied as shown in Fig. D.2.a.



IEC 1679/05

~~$U_{L1-N}=\sqrt{1+3P^2-(2\sqrt{3})P\cos(30^0)}$~~ ~~(C.3)~~

~~$\alpha=120^0-\sin^{-1}\left(\frac{P\sqrt{3}\sin(30^0)}{U_{L1-N}}\right)$~~ ~~(C.4)~~

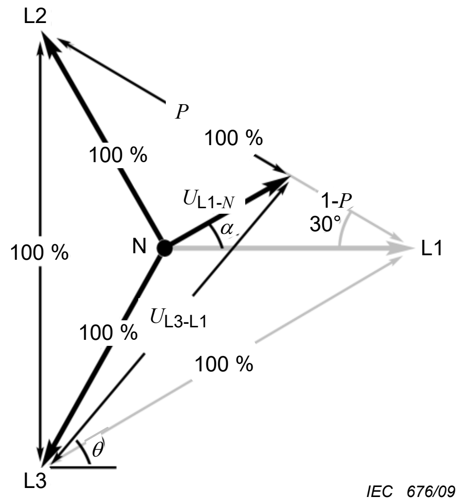
~~$U_{L3-L1}=\frac{\sqrt{1+(U_{L1-N})^2-2U_{L1-N}\cos(\alpha+120^0)}}{\sqrt{3}}$~~ ~~(C.5)~~

~~$\theta=60^0-\sin^{-1}\left(\frac{U_{L1-N}\sin(\alpha+120^0)}{\sqrt{3}U_{L3-L1}}\right)$~~ ~~(C.6)~~

~~*P* is the percent phase-to-phase dip, expressed as a fraction of the nominal phase-to-phase voltage.~~

~~U_{L1-N} is the voltage from L1 to Neutral (if a Neutral conductor exists), expressed as a fraction of the nominal phase-to-neutral voltage.~~

~~U_{L3-L1} is the voltage from L3 to L1, expressed as a fraction of the nominal phase-to-phase voltage.~~



IEC 676/09

$$U_{\mathrm{L1}-N}=\sqrt{1+3P^2-(2\sqrt{3})P\cos(30^\circ)} \quad (C.3)$$

$$\alpha=120^\circ-\sin^{-1}\left(\frac{P\sqrt{3}\sin(30^\circ)}{U_{\mathrm{L1}-N}}\right) \quad (C.4)$$

$$U_{\mathrm{L3-L1}}=\frac{\sqrt{1+(U_{\mathrm{L1}-N})^2-2U_{\mathrm{L1}-N}\cos(\alpha+120^\circ)}}{\sqrt{3}} \quad (C.5)$$

$$\theta=60^\circ-\sin^{-1}\left(\frac{U_{\mathrm{L1}-N}\sin(\alpha+120^\circ)}{\sqrt{3}U_{\mathrm{L3-L1}}}\right) \quad (C.6)$$

P is the percent phase-to-phase dip, expressed as a fraction of the nominal phase-to-phase voltage.

UL1-N is the voltage from L1 to Neutral (if a Neutral conductor exists), expressed as a fraction of the nominal phase-to-neutral voltage.

UL3-L1 is the voltage from L3 to L1, expressed as a fraction of the nominal phase-to-phase voltage.

NOTE The $\sin^{-1}$ function is ambiguous (there are always two angles that have the same value), and returns values between -90° and +90°, so the correct quadrant must be selected.

Figure C.2 – Acceptable Method 1 – phase-to-phase dip vectors

Table C.2 – Acceptable Method 1 – vector values for phase-to-phase dips

P	$U_{\text{L1-L2}}$	$U_{\text{L2-L3}}$	$U_{\text{L3-L1}}$	$U_{\text{L1-N}}$	$U_{\text{L2-N}}$	$U_{\text{L3-N}}$
100 % (no dip)	100 % 150°	100 % 270°	100 % 30°	100 % 0°	100 % 120°	100 % 240°
80 % L1-L2	80 % 150°	100 % 270°	92 % 41°	72 % 14°	100 % 120°	100 % 240°
80 % L2-L3	92 % 161°	80 % 270°	100 % 30°	100 % 0°	72 % 134°	100 % 240°
80 % L3-L1	100 % 150°	92 % 281°	80 % 30°	100 % 0°	100 % 120°	72 % 254°
70 % L1-L2	70 % 150°	100 % 270°	89 % 47°	61 % 25°	100 % 120°	100 % 240°
70 % L2-L3	89 % 167°	70 % 270°	100 % 30°	100 % 0°	61 % 145°	100 % 240°
70 % L3-L1	100 % 150°	89 % 287°	70 % 30°	100 % 0°	100 % 120°	61 % 265°
40 % L1-L2	40 % 150°	100 % 270°	87 % 67°	53 % 79°	100 % 120°	100 % 240°
40 % L2-L3	87 % 187°	40 % 270°	100 % 30°	100 % 0°	53 % 199°	100 % 240°
40 % L3-L1	100 % 150°	87 % 307°	40 % 30°	100 % 0°	100 % 120°	53 % 319°

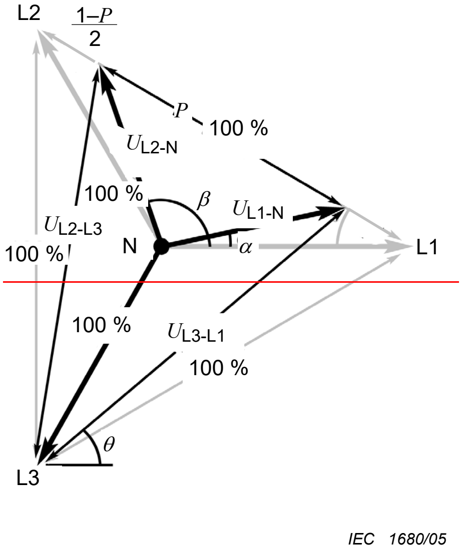
NOTE 1 "100 %" represents the voltage when no dip is present. For phase-to-phase voltages, this value will be higher than the 100 % phase-to-neutral value by a factor of $\sqrt{3}$.

NOTE 2 Phase-to-neutral voltages and angles are shown in this table, but are only used on systems with a neutral conductor. For systems that do not have a neutral conductor, ignore the phase-to-neutral columns

C.3 Acceptable Method 2 – phase-to-phase dip vectors

On three-phase systems, voltage dips are applied phase-to-phase, one pair of phases at a time (see 8.2.1). The vectors shown in Figure C.3 represent Acceptable Method 2 for phase-to-phase dips on three-phase systems. The example dip generator in Fig. D.3 might be used to generate these vectors. These vectors may be more representative of real-world dips than the vectors of C.2.

~~$U_{L1-N} = U_{L2-N} = \sqrt{1+\left(\sqrt{3}\,\frac{(1-P)}{2}\right)^2 - 2\left(\sqrt{3}\,\frac{(1-P)}{2}\right)\cos(30^0)}$ (C.7)~~



~~$\alpha = \sin^{-1}\left(\frac{\left(\sqrt{3}\,\frac{(1-P)}{2}\right)\sin(30^0)}{U_{L1-N}}\right)$ (C.8)~~

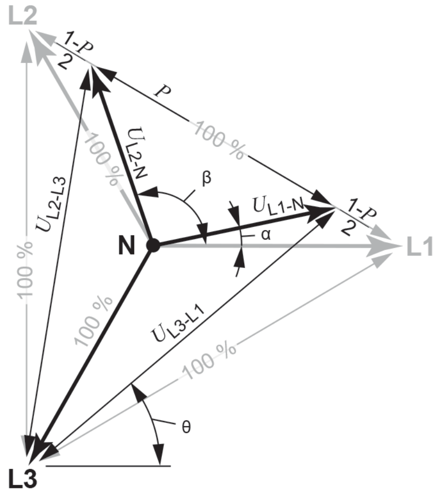
~~$\beta = 120^0 - \alpha$ (C.9)~~

~~$U_{L3-L1} = U_{L2-L3} = \frac{\sqrt{1+(U_{L1-N})^2 - 2(U_{L1-N})\cos(120^0+\alpha)}}{\sqrt{3}}$ (C.10)~~

~~$\theta = 60^0 - \sin^{-1}\left(\frac{U_{L1-N}\sin(120^0+\alpha)}{\sqrt{3}U_{L3-L1}}\right)$ (C.11)~~

~~P is the percent phase-to-phase dip, expressed as a fraction of the nominal phase-to-phase voltage.~~

~~$U_{\text{L1-N}}$ and $U_{\text{L2-N}}$ are the voltages from L1 or L2 to Neutral (if a Neutral conductor exists), expressed as a fraction of the nominal phase-to-neutral voltage.~~



IEC

$$U_{L1-N} = \frac{\sqrt{1+3P^2}}{2} \qquad \text{(C.7)}$$

$$\alpha = \sin^{-1}\left(\frac{\left(\sqrt{3}\,\frac{(1-P)}{2}\right)\sin(30^\circ)}{U_{\text{L1}-N}}\right) \qquad \text{(C.8)}$$

$$U_{\text{L3–L1}} = U_{\text{L2–L3}} = \frac{\sqrt{1+\left(U_{\text{L1}-N}\right)^2 - 2\left(U_{\text{L1}-N}\right)\cos(120^\circ+\alpha)}}{\sqrt{3}} \qquad \text{(C.9)}$$

$$\beta = 120^\circ - \alpha \qquad \text{(C.10)}$$

$$\theta = 60^\circ - \sin^{-1}\left(\frac{U_{\text{L1}-N}\sin(120^\circ+\alpha)}{\sqrt{3}U_{\text{L3–L1}}}\right) \qquad \text{(C.11)}$$

where

P	is the percent phase-to-phase dip, expressed as a fraction of the nominal phase-to-phase voltage.
$U_{\text{L1-}N}$ and $U_{\text{L2-}N}$	are the voltages from L1 or L2 to neutral (if a neutral conductor exists), expressed as a fraction of the nominal phase-to-neutral voltage.

NOTE The $\sin^{-1}$ function is ambiguous (there are always two angles that have the same value), and returns values between –90° and +90°, so the correct quadrant must be selected.

Figure C.3 – Acceptable Method 2 – phase-to-phase dip vectors

Table C.3 – Acceptable Method 2 – vector values for phase-to-phase dips

P	$U_{\text{L1-L2}}$	$U_{\text{L2-L3}}$	$U_{\text{L3-L1}}$	$U_{\text{L1-N}}$	$U_{\text{L2-N}}$	$U_{\text{L3-N}}$
100 % **(no dip)**	100 % 150°	100 % 270°	100 % 30°	100 % 0°	100 % 120°	100 % 240°
80 % **L1-L2**	80 % 150°	95 % 265°	95 % 35°	85 % 6°	85 % 114°	100 % 240°
80 % **L2-L3**	95 % 155°	80 % 270°	95 % 25°	100 % 0°	85 % 126°	85 % 234°
80 % **L3-L1**	95 % 145°	95 % 275°	80 % 30°	85 % -6°	100 % 120°	85 % 246°
70 % **L1-L2**	70 % 150°	93 % 262°	93 % 38°	79 % 10°	79 % 110°	100 % 240°
70 % **L2-L3**	93 % 158°	70 % 270°	93 % 22°	100 % 0°	79 % 130°	79 % 230°
70 % **L3-L1**	93 % 142°	93 % 278°	70 % 30°	79 % -10°	100 % 120°	79 % 250°
40 % **L1-L2**	40 % 150°	89 % 253°	89 % 47°	61 % 25°	61 % 95°	100 % 240°
40 % **L2-L3**	89 % 167°	40 % 270°	89 % 13°	100 % 0°	61 % 145°	61 % 215°
40 % **L3-L1**	89 % 133°	89 % 287°	40 % 30°	61 % -25°	100 % 120°	61 % 265°

NOTE 1 “100 %” represents the voltage when no dip is present. For phase-to-phase voltages, this value will be higher than the 100 % phase-to-neutral value by a factor of $\sqrt{3}$.

NOTE 2 Phase-to-neutral voltages and angles are shown in the table above, but are only used on systems with a neutral conductor. For systems that do not have a neutral conductor, ignore the phase-to-neutral columns.

Annex D
(informative)

Test instrumentation

Examples of generators and test set-ups

Figures D.1 and D.2 show two possible test configurations for mains supply simulation. These are simply examples; other configurations may be used.

In Figure D.1, voltage dips are simulated by alternately closing switch 1 and switch 2. These two switches are never closed at the same time and an interval up to 100 μs with the two switches opened is acceptable. It shall be possible to open and close the switches independently of the phase angle. Semiconductors switches constructed with power MOSFETs and IGBTs can fulfil this requirement. Thyristors and triacs open during current zero crossing, and therefore do not meet this requirement.

Wave-form generators and power amplifiers can be used instead of variable transformers and switches (see Figure D.3). This configuration also allows testing of the EUT in the context of frequency variations and harmonics.

Either of these types of generators can be used for single-phase testing, or for three-phase testing (for example, by connecting the example generator in D.1 between two phases as shown in Figure D.2).

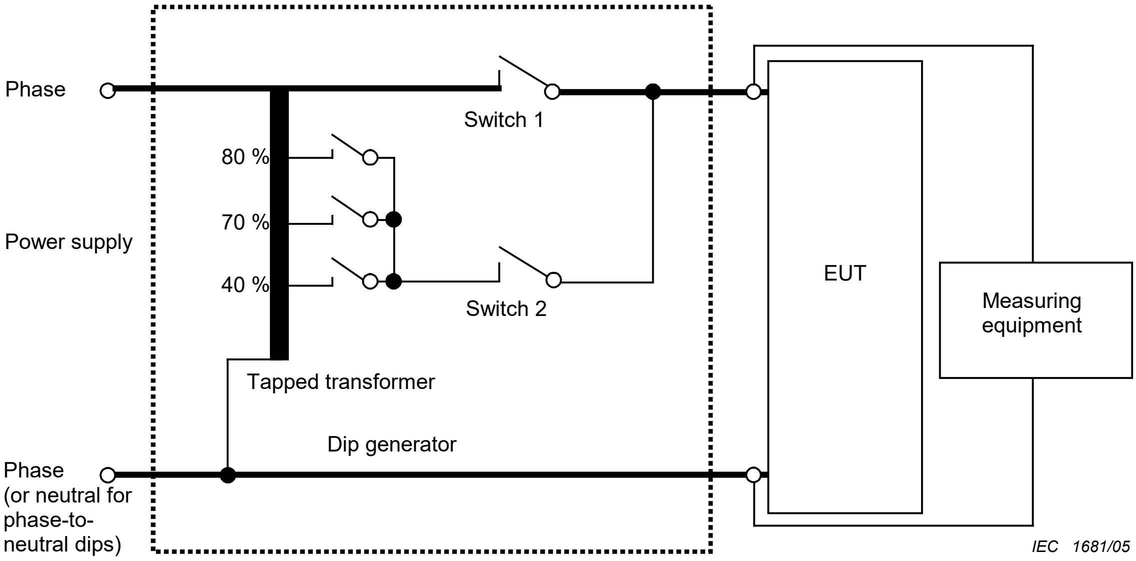
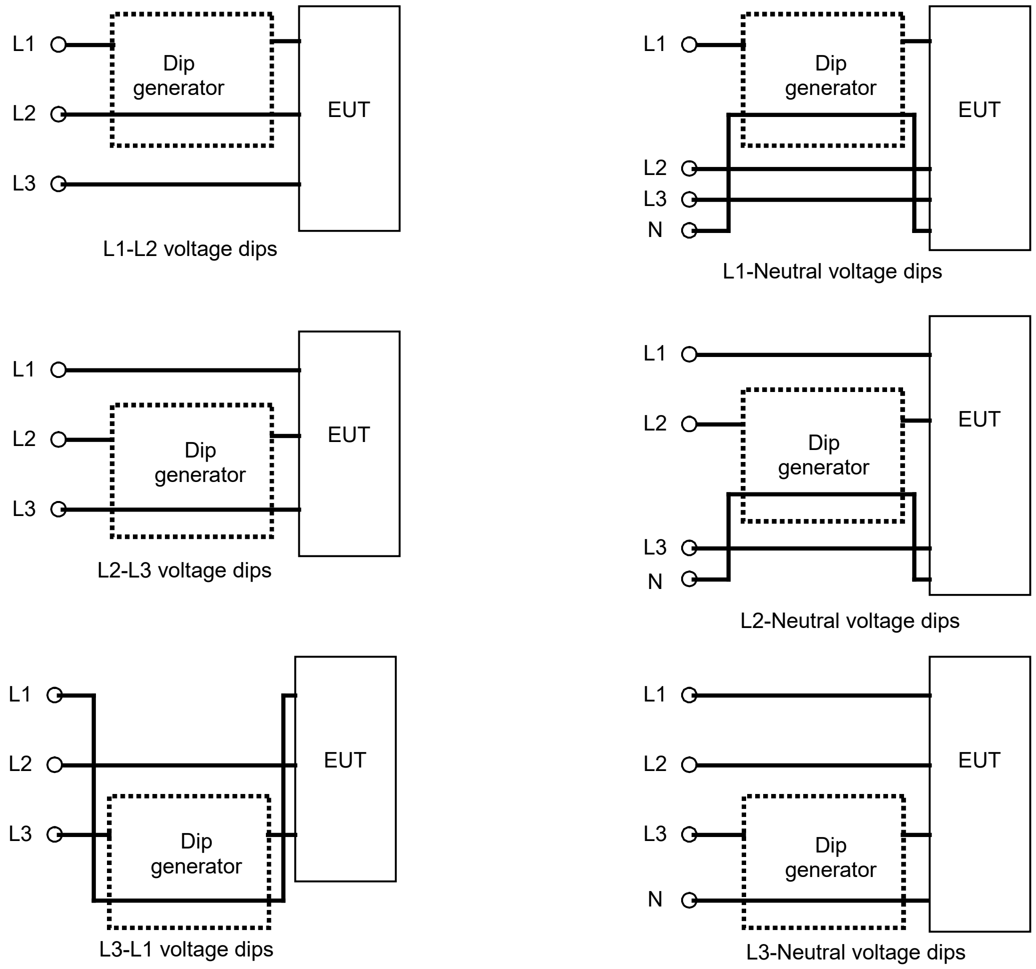


Figure D.1 – Schematic of example test instrumentation for voltage dips and short interruptions using tapped transformer and switches



D.2.a Phase-to-Phase dip **D.2.b Phase-to-Neutral dip**

IEC 1682/05

Figure D.2 – Applying the example test instrumentation of Figure D.1 to create the Acceptable Method 1 vectors of Figures C.1, C.2, 3b and 3c

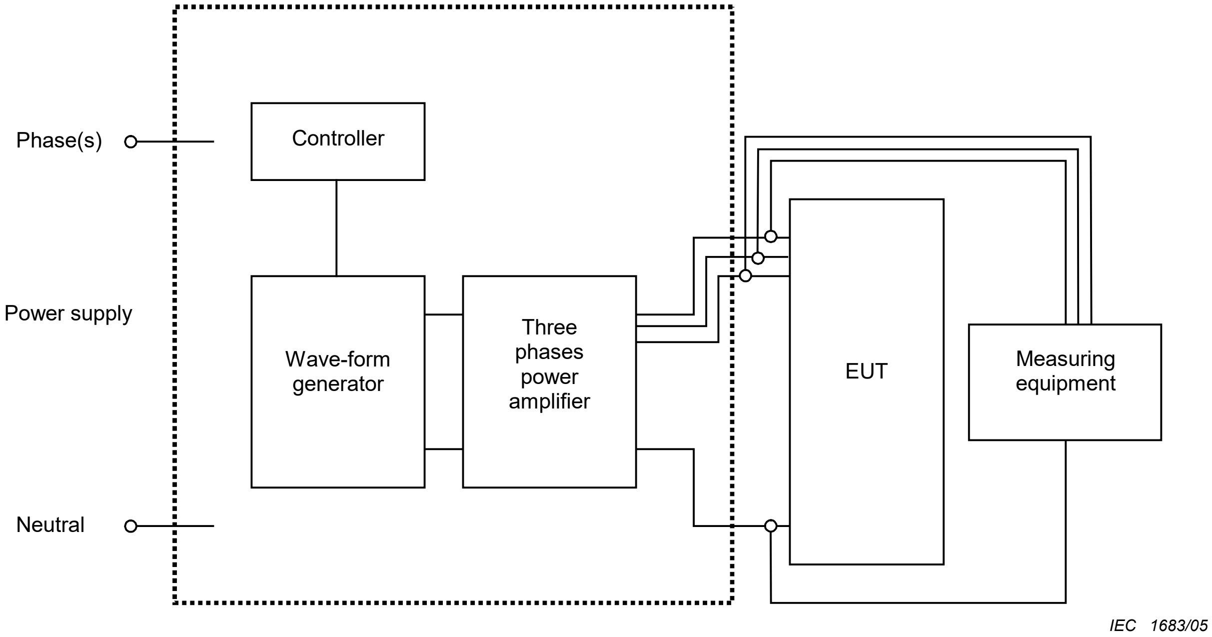


Figure D.3 – Schematic of example test instrumentation for three-phase voltage dips, short interruptions and voltage variations using power amplifier

Annex E
(informative)

Dip immunity tests for equipment with large mains current

E.1 General

This annex is provided as an informative complement to the normative part of this standard.

All loads may be affected by voltage dips, regardless of how large the load is. However, it may be difficult or impossible to perform voltage dip immunity testing on very large loads. This informative annex provides some guidance.

E.2 Considering the EUT current rating

First, determine the current rating of the Equipment Under Test (EUT).

If the EUT current rating is 16 A or less, do not use this standard. Use IEC 61000-4-11 instead.

If the EUT current rating is between 16 A and approximately 75 A, laboratory tests are preferred but in situ tests may be used, if necessary.

If the EUT current rating is between approximately 75 A and approximately 200 A, in-situ testing is probably required, because it will be difficult to transport the EUT to a laboratory.

If the EUT current rating is more than approximately 200 A it may be difficult to obtain test equipment and an appropriate test environment, for dip immunity testing. In this case, the following techniques should be considered.

NOTE “Approximately 75 A” and “approximately 200 A” were appropriate values at the time when this standard was written. Future changes in dip generator technology, or changes in EUT technology, may increase these values significantly. The values given here are intended for general guidance only.

E.3 Modular testing for large equipment

For the purpose of dip immunity testing, it may be possible to separate the EUT into modules of 200 A or less. Dip immunity testing can then be performed on each module individually and in accordance with this standard.

If this modular approach is selected, careful engineering judgement should be used to consider possible interactions between modules that are tested separately. For example, one module may generate an alarm signal during voltage dips, and another module may be responsible for responding to that alarm signal. These interactions may occur both during and after voltage dips.

E.4 Combined testing and simulation for large equipment

If modular testing of the complete EUT is impractical (for example, if one non-separable part of the EUT, such as a resistive heater, requires several hundred amperes), dip immunity testing should be performed on the sensitive parts of the EUT and engineering analysis/simulation should be applied to the remaining parts of the EUT.

For example, the sensitive parts may include electronic controls, computers, an emergency-off or emergency-stop system, phase rotation relays, undervoltage relays, etc. These parts of the EUT should be tested for immunity according to the standard, and engineering analysis and simulation are used for those modules which are impossible to test for immunity.

E.5 Considerations for voltage dip immunity analysis of very large equipment operation

Dip immunity testing, even of partial systems, is always preferred to simulation and analysis.

However, if engineering analysis and simulation are unavoidable, the following points should be carefully considered.

- The effects of unbalance during the voltage dips, including both magnitude and phase angle unbalance, especially on transformers and motors.
- The possible increase in current on the non-dipped phases during the dip, including its effect on components, connectors, protection devices such as fuses and circuit breakers, etc.
- The possible large increase in current immediately after the dip, including its effect on components, connectors, protection devices such as fuses and circuit breakers, etc.
- The response of safety functions to the voltage dip, including emergency-off and emergency-stop circuits, light curtains, etc.
- The possible effects of the dip on independently-powered sensors, and how those sensors may affect the behaviour of the EUT.
- The response of protective devices, both at the mains terminals of the EUT and at locations within the EUT, to changes in current during and after the dip.
- The response of mains sensing devices, such as phase rotation relays and undervoltage relays, to the voltage dip.
- The response of control relays and contactors, such as relays with 24 V AC coils, to the voltage dip.
- Error signals due to changes in water flow, air pressure, vacuum, etc. caused by brief changes in pump or fan rotation during voltage dips, and how these error signals may affect the EUT behaviour.
- The possible effects of component value variations. For example, electrolytic capacitors are often used as energy storage devices during voltage dips, and may have value tolerances of ±20 % or more.

This is not a complete list. It is offered for guidance only; careful engineering judgement should be applied.

Annex F
(informative)

Interpretation of the rise-time and fall-time requirements during EUT testing

In 2010 an interpretation sheet for IEC 61000-4-11:2004 (second edition) was issued. The contents of this interpretation sheet are similarly applicable to this standard:

Table 4 does not apply to EUT (equipment under test) testing. Table 4 is for generator calibration and design only.

a) With reference to Table 1 and Table 2, there is no requirement in this standard for rise-time and fall-time when testing EUT; therefore, it is not necessary to measure these parameters during tests.

b) 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, 50 Ω or 25 Ω resistor. The requirements of Table 4 do not apply during EUT testing.

Bibliography

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

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-14, *Electromagnetic compatibility (EMC) – Part 4-14: Testing and measurement techniques – Voltage fluctuation immunity test*

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase

FOREWORD

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This consolidated version of the official IEC Standard and its amendments has been prepared for user convenience.

IEC 61000-4-34 edition 1.2 contains the first edition (2005-10) [documents 77A/498/FDIS and 77A/515/RVD], its amendment 1 (2009-05) [documents 77A/670/CDV and 77A/688/RVC] and its corrigendum 1 (2009-10), and its amendment 2 (2025-08) [documents 77A/1233/CDV and 77A/1247/RVC].

This Final version does not show where the technical content is modified by amendments 1 and 2. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 61000-4-34 has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms Part 4-34 of IEC 61000. It has the status of a Basic EMC Publication in accordance with IEC Guide 107.

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

FDIS	Report on voting
77A/498/FDIS	77A/515/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 document and its amendments 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 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).

INTRODUCTION to Amendment 2

This amendment contains the following main changes in comparison with IEC 61000-4-34:2005 and IEC 61000-4-34:2005/AMD1:2009:

- Addition of a note in Annex C: The sign of phase angles of three-phase systems can differ depending on the convention used. It should be noted that phase angles opposite to those used in the figures and tables in this annex (i.e. -120° for L2 instead of +120°) are also common. It is not intended to specify the direction of rotation of the three-phase system used for testing.
- Add UL1-N = √(1+3P^2)/2 in Annex C.3,
- Add a new annex "Interpretation of the rise-time and fall-time requirements during EUT testing" (Annex F), as in IEC 61000-4-11:2020, Clause D.4:

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 mains current exceeding 16 A per phase. (See Annex E for guidance on electrical and electronic equipment rated at more than 200 A per phase.) It covers equipment installed in residential areas as well as industrial machinery, specifically voltage dips and short interruptions for equipment connected to either 50 Hz or 60 Hz a.c. networks, including 1-phase and 3-phase mains.

NOTE 1 Equipment with a rated mains current of 16 A or less per phase is covered by publication IEC 61000-4-11.

NOTE 2 There is no upper limit on rated mains current in this publication. However, in some countries, the rated mains current may be limited to some upper value, for example 75 A or 250 A, because of mandatory safety standards.

It does not apply to electrical and electronic equipment for connection to 400 Hz a.c. networks. Tests for equipment connected to 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 1 Voltage fluctuations are covered by publication IEC 61000-4-14.

NOTE 2 For equipment under test with rated currents above 250 A, suitable test equipment may be difficult to obtain. In these cases, the applicability of this standard should be carefully evaluated by committees responsible for generic, product and product-family standards. Alternatively, this standard might be used as a framework for an agreement on performance criteria between the manufacturer and the purchaser.

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

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*

IEC 61000-4-30, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161 as well as the following definitions apply:

3.1

basic EMC standard (ACEC)[1)]

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

3.2

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]

3.3

voltage dip

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

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 operation related to the occurrence and termination of short circuits on the system or installations connected to it.

3.5

residual voltage (of voltage dip)

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

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

3.7

calibration

set of operations which establishes, by reference to standards, the relationship which exists, under specified conditions, between an indication and a result of a measurement

NOTE 1 This term is based on the "uncertainty" approach.

NOTE 2 The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

[IEV 311-01-09]

[1)] Advisory Committee on Electromagnetic Compatibility (ACEC).

3.8
verification
set of operations which is used to check the test equipment system (e.g. the test generator and the interconnecting cables) and 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 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 so that the intended waveform is delivered to the EUT.

NOTE 3 For the purpose of this basic EMC standard this definition is different from the definition given in IEV 311-01-13.

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.

Voltage dips at equipment terminals are influenced by the transformer connections between the fault location on the supply system and the equipment connection point. The transformer connections will influence both the magnitude and the phase relationship of the voltage dip experienced by the equipment.

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 as a basis for voltage test level specification (U_T).

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;
- the selection of test levels and durations shall take into account the information given in IEC 61000-2-8.

5.1 Voltage dips and short interruptions

The change between U_T and the changed voltage is abrupt. Unless otherwise specified by the responsible product committee, the start and stop phase angle for the voltage dips and interruptions shall be 0° (i.e. the positive-going voltage zero-crossing on the dipped phase), See 8.2.1. The following test voltage levels (in % U_T) are used: 0 %, 40 %, 70 % and 80 %, corresponding to voltage dips or interruptions 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 1.

For short interruptions, the preferred test levels and durations are given in Table 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 test levels, for example 0 % test level for 1 s, and balanced three-phase dips, may be considered by product committees.

The voltage rise time, t_r, and voltage fall time, t_f, during abrupt changes are indicated in Table 4. Furthermore, additional information is given in Annex F with respect to the correct interpretation of rise-time and fall-time requirements during EUT testing.

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 an interruption.

Table 1 – Preferred test level and durations for voltage dips

Classes[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 1 cycle	70 % during 25/30[c] cycles		
Class 3	0 % during 1 cycle	40 %[d] during 10/12[c] cycles	70 % during 25/30[c] cycles	80 % during 250/300[c] cycles
Class X[b]	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 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", “10/12 cycles” means “10 cycles for 50 Hz test” and “12 cycles for 60 Hz test” and “250/300 cycles” means “250 cycles for 50 Hz test” and “300 cycles for 60 Hz test”.

[d] May be replaced by product committee with a test level of 50 % for equipment that is intended primarily for 200 V or 208 V nominal operation.

Table 2 – Preferred test level and durations for short interruptions

Classes[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 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.

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 voltages 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 rate 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_i) (50 Hz/60 Hz)**
70 %	Abrupt	1 cycle	25/30[b] cycles
X[a]	X[a]	X[a]	X[a]

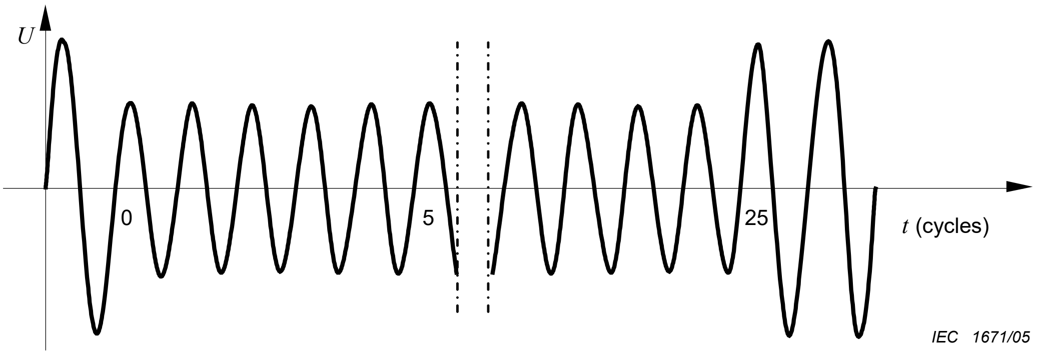
[a] To be defined by product committee.

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

For voltage variations in three-phase systems with or without neutral, all the three phases shall be tested simultaneously. Simultaneous voltage variations in three-phase systems are positioned at the zero-crossing of one of the voltages.

This shape is the typical shape of a motor starting with a rapid time for decreasing voltage, t_d, and slower time for increasing voltage, t_i.

Figure 2 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 cycles (50 Hz). Step at zero crossing.

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

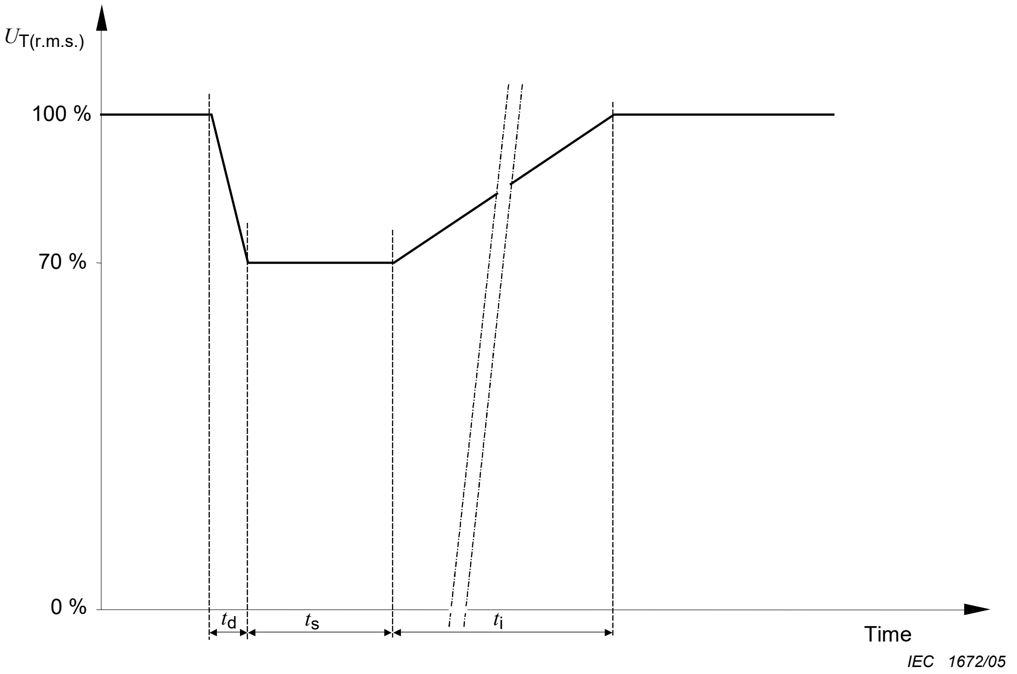


Figure 2 – Voltage variation

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 D.

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.

The output of the generator may be influenced by the generator characteristics, the load characteristics, and/or the characteristics of the a.c. network that supplies the generator.

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 at the output of the generator during equipment test	As required in Table 1, ±10 % of residual voltage value, measured as r.m.s. value refreshed each ½ cycle per IEC 61000-4-30
Output current capability	See Annex A
Peak inrush current capability (no requirement for voltage variation tests)	See Annex A
Instantaneous peak overshoot/undershoot of the actual voltage, generator loaded with resistive load – see NOTE 1	Less than 5 % of U_T
Voltage rise (and fall) time t_r (and t_f), during abrupt change, generator loaded with resistive load – see NOTE A and NOTE 1	Between 1 μs and 5 μs for current ≤75 A Between 1 μs and 50 μs for current >75 A
Phase angle at which the voltage dip begins and ends	0° to 360° with a maximum resolution of 5°, see NOTE B
Phase relationship of voltage dips and interruptions with the power frequency	Less than ±5°
Zero crossing control of the generators	±10°
NOTE A These values must be checked with a resistive load as per NOTE 1 after this table, but they need not be checked when an EUT is connected. NOTE B Phase angle adjustment may be required to comply with 5.1.	

Output impedance shall be predominantly resistive.

The output impedance of the test voltage generator shall be low even during transitions when generating dips. A brief interval (up to 100 µs) of high impedance is permitted during each transition. For generating interruptions, a high impedance open circuit is permited.

NOTE 1 The value of the non-inductive resistive load for testing overshoot, undershoot, rise time, and fall time shall be 100 ohms for generators rated for 50 A or less, 50 ohms for generators rated for more than 50 A and less or equal than 100 A, and 25 ohms for generators rated more than 100 A.

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

NOTE 3 A high-impedance interruption, when applied to an inductive load, may generate substantial over-voltages.

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 the specified percentage of the U_T;
- the voltage at the output of the generator shall be monitored during tests as an r.m.s. value refreshed each ½ cycle, and shall be maintained within the specified percentage throughout the tests.

NOTE If it can be demonstrated that the equipment peak current requirements are sufficiently small as not to influence the voltage at the output of the generator, it is not necessary to monitor the output voltage during tests.

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 315° 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°.

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.

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 (optional).

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

8 Test procedures

Caution should be exercised during the set-up and execution of these tests. EUT and test equipment shall not become dangerous or unsafe as a result of the application of the tests defined in this part of IEC 61000. Precautions should be taken to avoid dangerous and unsafe situations for personnel, the EUT, and the test equipment.

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 intended to be 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;
- information about the inrush current requirements of the equipment;
- 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.

8.1 Laboratory reference conditions

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 be such as to guarantee the correct operation of the EUT in order not to influence the test results.

8.2 Execution of the test

During the tests, the mains voltage for testing shall be monitored within an accuracy of 2 %.

8.2.1 Voltage dips and short interruptions

The EUT shall be tested for each selected combination of test level and duration with a sequence of three dips/interruptions with intervals of 10 s minimum (between each test event). Each representative mode of operation shall be tested.

For voltage dips, changes in supply voltage shall occur at 0° (positive-going zero crossing of the voltage). Additional angles considered critical may be selected by product committees or individual product specifications preferably from 45°, 90°, 135°, 180°, 225°, 270° and 315° on each phase.

For short interruptions, the starting angle shall be defined by the product committee as the worst case. In the absence of definition, it is recommended to use 0° for one of the phases.

For short interruptions test of three-phase systems, all the three phases shall be simultaneously tested as per 5.1.

For voltage dips test of single-phase systems, the voltage shall be tested as per 5.1. This implies one series of tests.

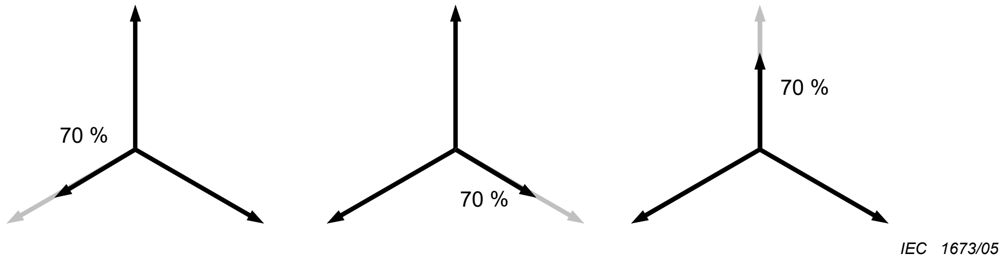
For voltage dips test of three-phase systems with neutral, each individual voltage (phase-to-neutral and phase-to-phase) shall be tested, one at a time, as per 5.1. This implies six different series of tests. See Figure 3a, Figure 3b and Figure 3c.

For voltage dips test of three-phase systems without neutral, each phase-to-phase voltage shall be tested, one at a time, as per 5.1. This implies three different series of tests. See Annex C. See Figure 3b and Figure 3c.

NOTE 1 For three-phase systems, during a dip on a phase-to-phase voltage, a change will occur on one or two of the other voltages as well.

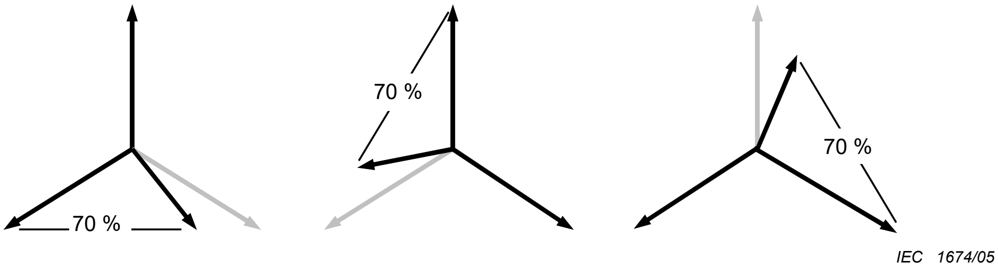
NOTE 2 For phase-to-phase testing on three-phase systems, the vectors of Figure 3b represents Acceptable Method 1, and the vectors of Figure 3c represent Acceptable Method 2. The Acceptable Method 1 vectors shown in Figure 3b may be easier for test labs to generate. See Annex D, Figure D.1. The Acceptable Method 2 vectors shown in Figure 3c may be more representative of real-world dips. There may be significant differences between results when comparing the vectors of Figure 3b to the vectors of Figure 3c.

For EUTs with more than one power cord, each power cord should be tested individually.



NOTE Phase-to-neutral testing on three-phase systems is performed one phase at a time.

Figure 3a – Phase-to-neutral testing on three-phase systems



NOTE Phase-to-phase testing on three-phase systems is also performed one phase at a time

Figure 3b – Phase-to-phase testing on three-phase systems – Acceptable Method 1 phase shift

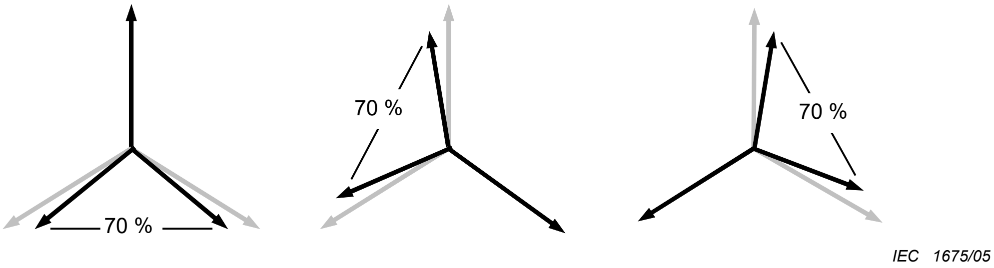


Figure 3c – Phase-to-phase testing on three-phase systems – Acceptable Method 2 phase shift

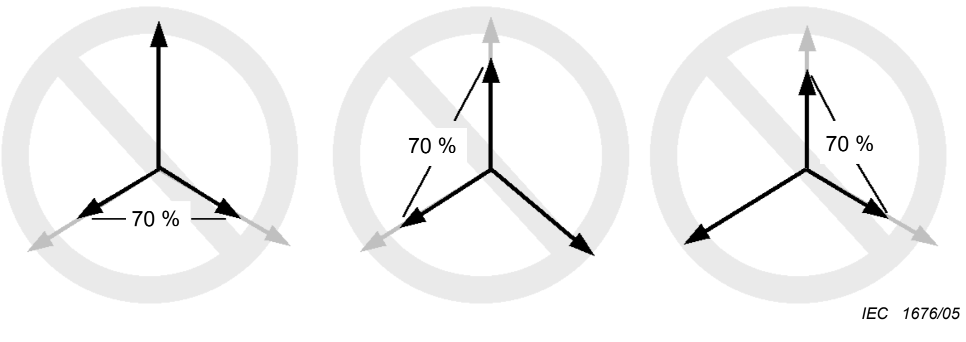


Figure 3d – Not acceptable – phase-to-phase testing without phase shift

Figure 3 – Testing on three-phase systems

8.2.2 Voltage variations (optional)

The EUT is tested to each of the specified voltage variations, three times at 10 s intervals for the most representative modes of operations.

9 Evaluation of test results

The test results shall be classified in terms of the loss of function or degradation of performance of the equipment under test, relative to a performance level defined by its manufacturer or the requestor of the test, or agreed between the manufacturer and the purchaser of the product. The recommended classification is as follows:

a) normal performance within limits specified by the manufacturer, requestor or purchaser;
b) temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention;
c) temporary loss of function or degradation of performance, the correction of which requires operator intervention;
d) loss of function or degradation of performance which is not recoverable, owing to damage to hardware or software, or loss of data.

The manufacturer's specification may define effects on the EUT which may be considered insignificant, and therefore acceptable.

This classification may be used as a guide in formulating performance criteria, by committees responsible for generic, product and product-family standards, or as a framework for the agreement on performance criteria between the manufacturer and the purchaser, for example where no suitable generic, product or product-family standard exists.

NOTE The performance levels may be different for voltage dip tests and short interruption tests as well as for voltage variations test, if this optional test has been required.

10 Test report

The test report shall contain all the information necessary to reproduce the test. In particular, the following shall be recorded:

- the items specified in the test plan required by Clause 8;
- identification of the EUT and any associated equipment, e.g. brand name, product type, serial number;
- identification of the test equipment, e.g. brand name, product type, serial number;
- any special environmental conditions in which the test was performed, for example shielded enclosure;
- any specific conditions necessary to enable the test to be performed;
- performance level defined by the manufacturer, requestor or purchaser;
- performance criterion specified in the generic, product or product-family standard;
- any effects on the EUT observed during or after the application of the test disturbance, and the duration for which these effects persist;
- the rationale for the pass/fail decision (based on the performance criterion specified in the generic, product or product-family standard, or agreed between the manufacturer and the purchaser);
- any specific conditions of use, for example cable length or type, shielding or grounding, or EUT operating conditions, which are required to achieve compliance.

Annex A
(normative)

Test generator current drive capability

During voltage dip testing, equipment peak inrush current may greatly exceed equipment rated current. The peak inrush current may occur at any time during the equipment process, not necessarily when power is first applied to the equipment.

During voltage dip testing on polyphase loads, the current on non-dipped phases may increase to as much as 200 % of the rated current, for the duration of the dip.

Current capability at the output of a test generator may be a function of both the test generator and of the a.c. mains source that supplies power to the test generator.

A.1 Test generator inrush current requirement

The test generator shall be capable of supplying the peak inrush current shown in Table A.1.

Table A.1 – Minimum peak inrush current capability

Rated current of Equipment	Minimum peak inrush current capability of the generator
16 A – 50 A	500 A
50,1 A – 100 A	1 000 A
More than 100 A	Not less than 1 000 A, and sufficient to maintain ±10 % of required voltage value during maximum peak inrush, measured as r.m.s. value refreshed each ½ cycle per IEC 61000-4-30.

A.2 Measuring test generator peak inrush current drive capability

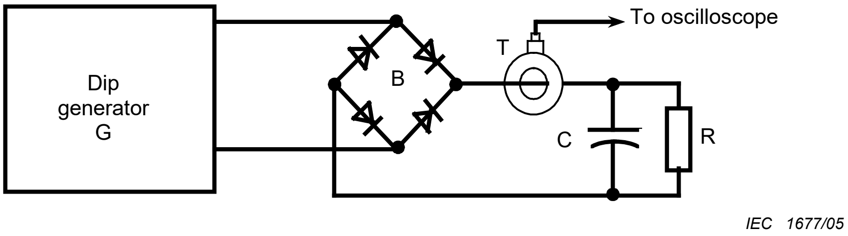
The circuit for measuring generator peak inrush current drive capability is shown in Figure A.1. Use of the bridge rectifier makes it unnecessary to change rectifier polarity for tests at 270° versus 90°.

The 1 700 µF electrolytic capacitor shall have a tolerance of ±20 %. It shall have a voltage rating preferably 15 % – 20 % in excess of the nominal peak voltage of the mains, for example 400 V for 220 V – 240 V mains. The capacitor shall have the lowest possible equivalent series resistance (ESR) at both 100 Hz and 20 kHz, and the peak inrush current shall not be limited by the capacitor ESR. Multiple capacitors may be paralleled to achieve sufficiently low ESR.

Since the test shall be performed with the 1 700 µF capacitor discharged, a resistor shall be connected in parallel with it and several time constants (RC) must be allowed between tests. With a 10 000 Ω resistor, the RC time constant is 17 s, so that a wait of 1,5 min to 2 min should be used between inrush drive capability tests. Resistors as low as 100 Ω may be used when shorter wait times are desired.

The current probe shall be able to accommodate the full generator peak inrush current drive for one-quarter cycle without saturation.

Tests shall be run by switching the generator output from 0 % to 100 % at both 90° and 270°, to ensure sufficient peak inrush current drive capability for both polarities.



Components

G	test voltage generator, switched on at 90° and 270°
T	current probe, with monitoring output to oscilloscope
B	rectifier bridge
R	bleeder resistor, not over 10 000 Ω or less than 100 Ω
C	1 700 μF ±20 % electrolytic capacitor

Figure A.1 – Circuit for determining inrush current drive capability

A.3 Test generator requirement during dip current

During dip tests on polyphase loads, the test generator shall be capable of supplying sufficient current on the non-dipped phase conductors, during the dip, to maintain the voltages required in Table 1, ±10 %, measured as r.m.s. value (average time 1 cycle) refreshed each ½ cycle as per IEC 61000-4-30.

NOTE During the dip, the current on the non-dipped phase conductors may be as much as 200 % of the rated current.

Annex B
(informative)

Electromagnetic environment classes

The following electromagnetic environment classes have been summarised from IEC 61000-2-4.

Class 1

This class applies to protected supplies and has compatibility levels lower than public network levels. It relates to the use of equipment very sensitive to disturbances in the power supply, for instance the instrumentation of technological laboratories, some automation and protection equipment, some computers, etc.

NOTE Class 1 environments normally contain equipment which requires protection by such apparatus as uninterruptible power supplies (UPS), filters, or surge suppressers.

Class 2

This class applies to points of common coupling (PCCs for consumer systems) and in-plant points of common coupling (IPCs) in the industrial environment in general. The compatibility levels in this class are identical to those of public networks; therefore components designed for application in public networks may be used in this class of industrial environment.

Class 3

This class applies only to IPCs in industrial environments. It has higher compatibility levels than those of class 2 for some disturbance phenomena. For instance, this class should be considered when any of the following conditions are met:

– a major part of the load is fed through converters;

– welding machines are present;

– large motors are frequently started;

– loads vary rapidly

NOTE 1 The supply to highly disturbing loads, such as arc-furnaces and large converters which are generally supplied from a segregated bus-bar, frequently has disturbance levels in excess of class 3 (harsh environment). In such special situations, the compatibility levels should be agreed upon.

NOTE 2 The class applicable for new plants and extensions of existing plants should relate to the type of equipment and process under consideration.

Annex C
(informative)

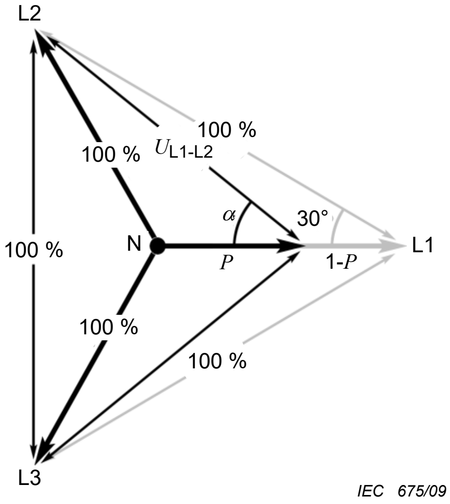
Vectors for three-phase testing

The graphs, equations, and tables in this annex all assume that the neutral conductor is electrically centered between the three phase conductors. For electrical systems in which the neutral is not electrically centered, different vectors must be created.

NOTE The phase angles of three-phase systems can differ depending on the convention used. It is noted that phase angles opposite to those used in the figures and tables in Annex C (i.e. -120° for L2 instead of +120°) are also common. It is not intended to specify the direction of rotation of the three-phase system used for testing.

C.1 Phase-to-neutral dip vectors

Voltage dips are applied phase-to-neutral, one phase at a time (see 8.2.1). The example dip generator in Fig. D.1 generates these vectors when applied as shown in Fig. D.2.b.



$$\alpha = \sin^{-1}\left(\frac{\sin(120^\circ)}{\sqrt{1+P^2-2P\cos(120^\circ)}}\right) \quad (C.1)$$

$$U_{\text{L1–L2}} = \frac{\sqrt{1+P^2-2P\cos(120^\circ)}}{\sqrt{3}} \quad (C.2)$$

P is the percent phase-to-neutral dip, expressed as a fraction of the nominal phase-to-neutral voltage.

UL1-L2 is the voltage from L1 to L2, expressed as a fraction of the nominal phase-to-phase voltage.

NOTE The sin–1 function is ambiguous (there are always two angles that have the same value), and return values between –90° and +90°, so the correct quadrant must be selected.

Figure C.1 – Phase-to-neutral dip vectors

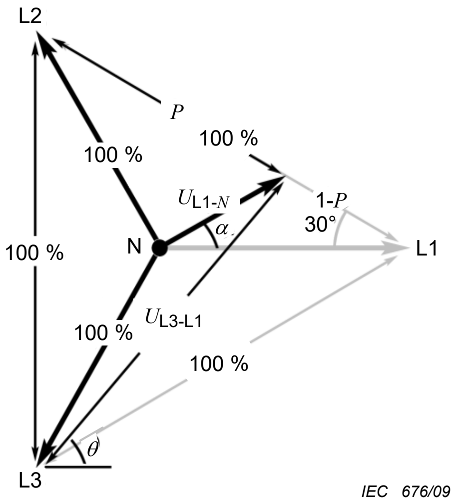
Table C.1 – Vector values for phase-to-neutral dips

P	$U_{\text{L1-L2}}$	$U_{\text{L2-L3}}$	$U_{\text{L3-L1}}$	$U_{\text{L1-N}}$	$U_{\text{L2-N}}$	$U_{\text{L3-N}}$
100 % **(no dip)**	100 % 150°	100 % 270°	100 % 30°	100 % 0°	100 % 120°	100 % 240°
80 % **L1-N**	90 % 146°	100 % 270°	90 % 34°	80 % 0°	100 % 120°	100 % 240°
80 % **L2-N**	90 % 154°	90 % 266°	100 % 30°	100 % 0°	80 % 120°	100 % 240°
80 % **L3-N**	100 % 150°	90 % 274°	90 % 26°	100 % 0°	100 % 120°	80 % 240°
70 % **L1-N**	85 % 144°	100 % 270°	85 % 36°	70 % 0°	100 % 120°	100 % 240°
70 % **L2-N**	85 % 156°	85 % 264°	100 % 30°	100 % 0°	70 % 120°	100 % 240°
70 % **L3-N**	100 % 150°	85 % 276°	85 % 24°	100 % 0°	100 % 120°	70 % 240°
40 % **L1-N**	72 % 136°	100 % 270°	72 % 44°	40 % 0°	100 % 120°	100 % 240°
40 % **L2-N**	72 % 164°	72 % 256°	100 % 30°	100 % 0°	40 % 120°	100 % 240°
40 % **L3-N**	100 % 150°	72 % 284°	72 % 16°	100 % 0°	100 % 120°	40 % 240°

NOTE “100 %” represents the voltage when no dip is present. For phase-to-phase voltages, this value will be higher than the 100 % phase-to-neutral value by a factor of $\sqrt{3}$.

C.2 Acceptable Method 1 – phase-to-phase dip vectors

On three-phase systems, voltage dips are applied phase-to-phase, one pair of phases at a time (see 8.2.1). The vectors shown in Figure C.2 represent Acceptable Method 1 for phase-to-phase dips on three-phase systems. The example dip generator in Fig. D.1 generates these vectors when applied as shown in Fig. D.2.a.



$$U_{L1-N} = \sqrt{1 + 3P^2 - (2\sqrt{3})P\cos(30^\circ)} \qquad \text{(C.3)}$$

$$\alpha = 120^\circ - \sin^{-1}\left(\frac{P\sqrt{3}\sin(30^\circ)}{U_{L1-N}}\right) \qquad \text{(C.4)}$$

$$U_{L3-L1} = \frac{\sqrt{1 + (U_{L1-N})^2 - 2U_{L1-N}\cos(\alpha + 120^\circ)}}{\sqrt{3}} \qquad \text{(C.5)}$$

$$\theta = 60^\circ - \sin^{-1}\left(\frac{U_{L1-N}\sin(\alpha + 120^\circ)}{\sqrt{3}U_{L3-L1}}\right) \qquad \text{(C.6)}$$

P is the percent phase-to-phase dip, expressed as a fraction of the nominal phase-to-phase voltage.

UL1-N is the voltage from L1 to Neutral (if a Neutral conductor exists), expressed as a fraction of the nominal phase-to-neutral voltage.

UL3-L1 is the voltage from L3 to L1, expressed as a fraction of the nominal phase-to-phase voltage.

NOTE The sin^{-1} function is ambiguous (there are always two angles that have the same value), and returns values between -90° and +90°, so the correct quadrant must be selected.

Figure C.2 – Acceptable Method 1 – phase-to-phase dip vectors

Table C.2 – Acceptable Method 1 – vector values for phase-to-phase dips

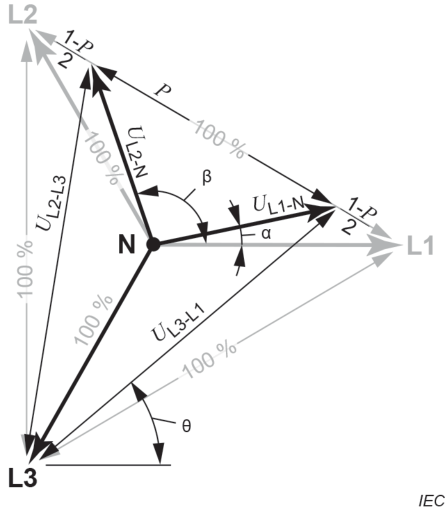
P	$U_{\mathrm{L1\text{-}L2}}$	$U_{\mathrm{L2\text{-}L3}}$	$U_{\mathrm{L3\text{-}L1}}$	$U_{\mathrm{L1\text{-}N}}$	$U_{\mathrm{L2\text{-}N}}$	$U_{\mathrm{L3\text{-}N}}$
100 % (no dip)	100 % 150°	100 % 270°	100 % 30°	100 % 0°	100 % 120°	100 % 240°
80 % L1-L2	80 % 150°	100 % 270°	92 % 41°	72 % 14°	100 % 120°	100 % 240°
80 % L2-L3	92 % 161°	80 % 270°	100 % 30°	100 % 0°	72 % 134°	100 % 240°
80 % L3-L1	100 % 150°	92 % 281°	80 % 30°	100 % 0°	100 % 120°	72 % 254°
70 % L1-L2	70 % 150°	100 % 270°	89 % 47°	61 % 25°	100 % 120°	100 % 240°
70 % L2-L3	89 % 167°	70 % 270°	100 % 30°	100 % 0°	61 % 145°	100 % 240°
70 % L3-L1	100 % 150°	89 % 287°	70 % 30°	100 % 0°	100 % 120°	61 % 265°
40 % L1-L2	40 % 150°	100 % 270°	87 % 67°	53 % 79°	100 % 120°	100 % 240°
40 % L2-L3	87 % 187°	40 % 270°	100 % 30°	100 % 0°	53 % 199°	100 % 240°
40 % L3-L1	100 % 150°	87 % 307°	40 % 30°	100 % 0°	100 % 120°	53 % 319°

NOTE 1 "100 %" represents the voltage when no dip is present. For phase-to-phase voltages, this value will be higher than the 100 % phase-to-neutral value by a factor of $\sqrt{3}$.

NOTE 2 Phase-to-neutral voltages and angles are shown in this table, but are only used on systems with a neutral conductor. For systems that do not have a neutral conductor, ignore the phase-to-neutral columns

C.3 Acceptable Method 2 – phase-to-phase dip vectors

On three-phase systems, voltage dips are applied phase-to-phase, one pair of phases at a time (see 8.2.1). The vectors shown in Figure C.3 represent Acceptable Method 2 for phase-to-phase dips on three-phase systems. The example dip generator in Fig. D.3 might be used to generate these vectors. These vectors may be more representative of real-world dips than the vectors of C.2.



$$U_{L1-N} = \frac{\sqrt{1+3P^2}}{2} \qquad \text{(C.7)}$$

$$\alpha = \sin^{-1}\left(\frac{\left(\sqrt{3}\,\dfrac{(1-P)}{2}\right)\sin(30^\circ)}{U_{\text{L1}-N}}\right) \qquad \text{(C.8)}$$

$$U_{\text{L3-L1}} = U_{\text{L2-L3}} = \frac{\sqrt{1+\left(U_{\text{L1}-N}\right)^2 - 2\left(U_{\text{L1}-N}\right)\cos(120^\circ+\alpha)}}{\sqrt{3}} \qquad \text{(C.9)}$$

$$\beta = 120^\circ - \alpha \qquad \text{(C.10)}$$

$$\theta = 60^\circ - \sin^{-1}\left(\frac{U_{\text{L1}-N}\sin(120^\circ+\alpha)}{\sqrt{3}U_{\text{L3-L1}}}\right) \qquad \text{(C.11)}$$

where

P	is the percent phase-to-phase dip, expressed as a fraction of the nominal phase-to-phase voltage.
$U_{\text{L1-}N}$ and $U_{\text{L2-}N}$	are the voltages from L1 or L2 to neutral (if a neutral conductor exists), expressed as a fraction of the nominal phase-to-neutral voltage.

NOTE The $\sin^{-1}$ function is ambiguous (there are always two angles that have the same value), and returns values between –90° and +90°, so the correct quadrant must be selected.

Figure C.3 – Acceptable Method 2 – phase-to-phase dip vectors

Table C.3 – Acceptable Method 2 – vector values for phase-to-phase dips

P	$U_{\text{L1-L2}}$	$U_{\text{L2-L3}}$	$U_{\text{L3-L1}}$	$U_{\text{L1-N}}$	$U_{\text{L2-N}}$	$U_{\text{L3-N}}$
100 % (no dip)	100 % 150°	100 % 270°	100 % 30°	100 % 0°	100 % 120°	100 % 240°
80 % L1-L2	80 % 150°	95 % 265°	95 % 35°	85 % 6°	85 % 114°	100 % 240°
80 % L2-L3	95 % 155°	80 % 270°	95 % 25°	100 % 0°	85 % 126°	85 % 234°
80 % L3-L1	95 % 145°	95 % 275°	80 % 30°	85 % -6°	100 % 120°	85 % 246°
70 % L1-L2	70 % 150°	93 % 262°	93 % 38°	79 % 10°	79 % 110°	100 % 240°
70 % L2-L3	93 % 158°	70 % 270°	93 % 22°	100 % 0°	79 % 130°	79 % 230°
70 % L3-L1	93 % 142°	93 % 278°	70 % 30°	79 % -10°	100 % 120°	79 % 250°
40 % L1-L2	40 % 150°	89 % 253°	89 % 47°	61 % 25°	61 % 95°	100 % 240°
40 % L2-L3	89 % 167°	40 % 270°	89 % 13°	100 % 0°	61 % 145°	61 % 215°
40 % L3-L1	89 % 133°	89 % 287°	40 % 30°	61 % -25°	100 % 120°	61 % 265°

NOTE 1 "100 %" represents the voltage when no dip is present. For phase-to-phase voltages, this value will be higher than the 100 % phase-to-neutral value by a factor of $\sqrt{3}$.

NOTE 2 Phase-to-neutral voltages and angles are shown in the table above, but are only used on systems with a neutral conductor. For systems that do not have a neutral conductor, ignore the phase-to-neutral columns.

Annex D
(informative)

Test instrumentation

Examples of generators and test set-ups

Figures D.1 and D.2 show two possible test configurations for mains supply simulation. These are simply examples; other configurations may be used.

In Figure D.1, voltage dips are simulated by alternately closing switch 1 and switch 2. These two switches are never closed at the same time and an interval up to 100 µs with the two switches opened is acceptable. It shall be possible to open and close the switches independently of the phase angle. Semiconductors switches constructed with power MOSFETs and IGBTs can fulfil this requirement. Thyristors and triacs open during current zero crossing, and therefore do not meet this requirement.

Wave-form generators and power amplifiers can be used instead of variable transformers and switches (see Figure D.3). This configuration also allows testing of the EUT in the context of frequency variations and harmonics.

Either of these types of generators can be used for single-phase testing, or for three-phase testing (for example, by connecting the example generator in D.1 between two phases as shown in Figure D.2).

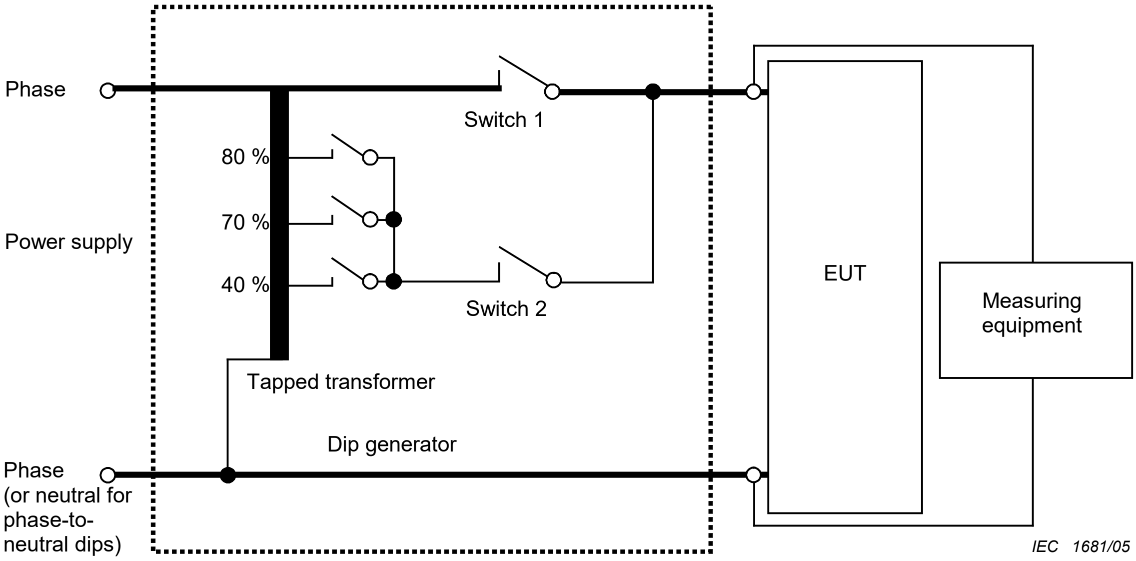
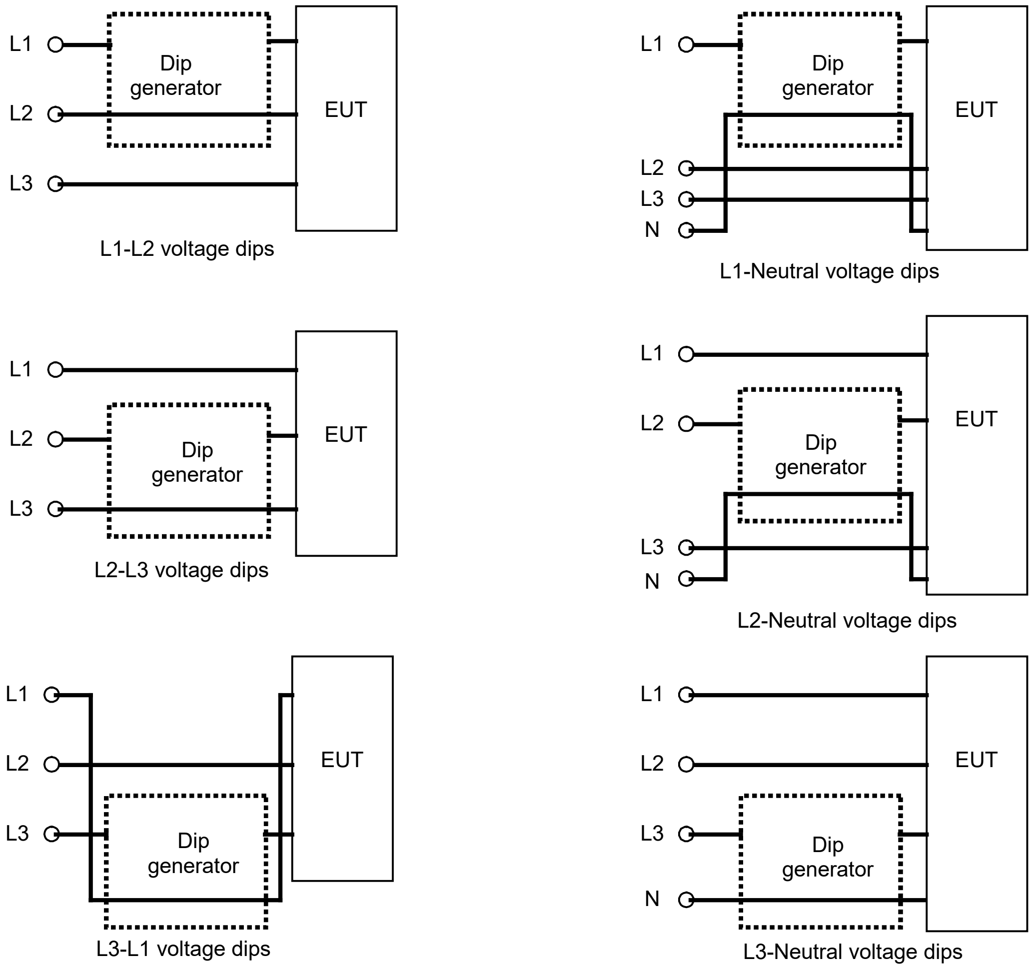


Figure D.1 – Schematic of example test instrumentation for voltage dips and short interruptions using tapped transformer and switches



D.2.a Phase-to-Phase dip

D.2.b Phase-to-Neutral dip

IEC 1682/05

Figure D.2 – Applying the example test instrumentation of Figure D.1 to create the Acceptable Method 1 vectors of Figures C.1, C.2, 3b and 3c

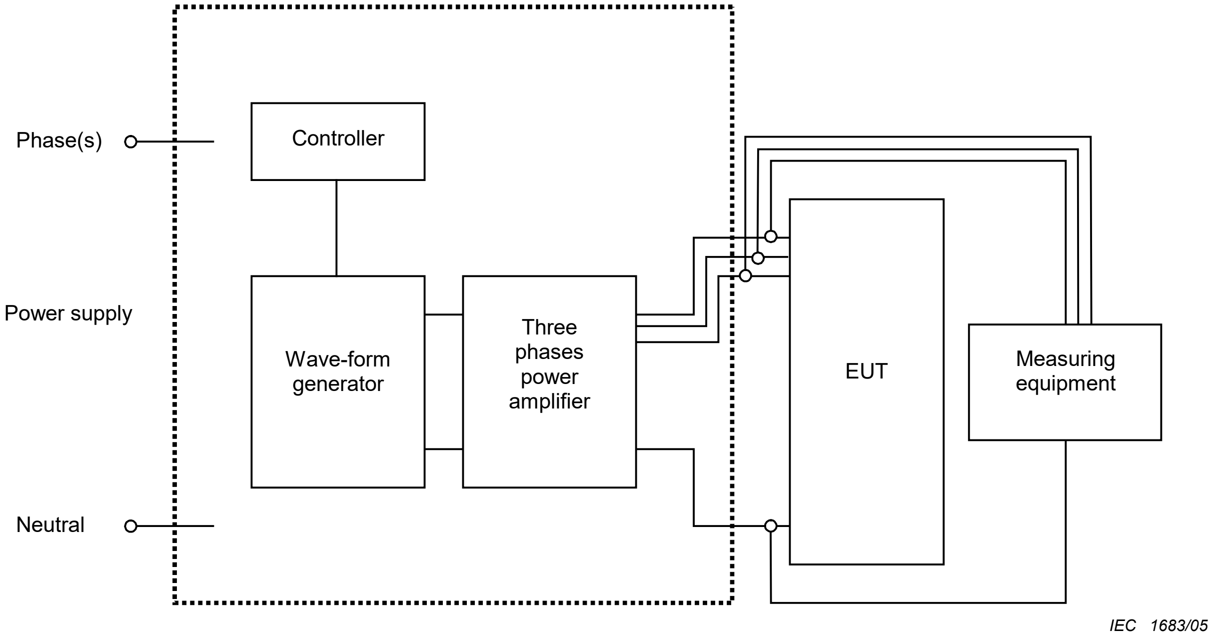


Figure D.3 – Schematic of example test instrumentation for three-phase voltage dips, short interruptions and voltage variations using power amplifier

Annex E
(informative)

Dip immunity tests for equipment with large mains current

E.1 General

This annex is provided as an informative complement to the normative part of this standard.

All loads may be affected by voltage dips, regardless of how large the load is. However, it may be difficult or impossible to perform voltage dip immunity testing on very large loads. This informative annex provides some guidance.

E.2 Considering the EUT current rating

First, determine the current rating of the Equipment Under Test (EUT).

If the EUT current rating is 16 A or less, do not use this standard. Use IEC 61000-4-11 instead.

If the EUT current rating is between 16 A and approximately 75 A, laboratory tests are preferred but in situ tests may be used, if necessary.

If the EUT current rating is between approximately 75 A and approximately 200 A, in-situ testing is probably required, because it will be difficult to transport the EUT to a laboratory.

If the EUT current rating is more than approximately 200 A it may be difficult to obtain test equipment and an appropriate test environment, for dip immunity testing. In this case, the following techniques should be considered.

NOTE "Approximately 75 A" and "approximately 200 A" were appropriate values at the time when this standard was written. Future changes in dip generator technology, or changes in EUT technology, may increase these values significantly. The values given here are intended for general guidance only.

E.3 Modular testing for large equipment

For the purpose of dip immunity testing, it may be possible to separate the EUT into modules of 200 A or less. Dip immunity testing can then be performed on each module individually and in accordance with this standard.

If this modular approach is selected, careful engineering judgement should be used to consider possible interactions between modules that are tested separately. For example, one module may generate an alarm signal during voltage dips, and another module may be responsible for responding to that alarm signal. These interactions may occur both during and after voltage dips.

E.4 Combined testing and simulation for large equipment

If modular testing of the complete EUT is impractical (for example, if one non-separable part of the EUT, such as a resistive heater, requires several hundred amperes), dip immunity testing should be performed on the sensitive parts of the EUT and engineering analysis/simulation should be applied to the remaining parts of the EUT.

For example, the sensitive parts may include electronic controls, computers, an emergency-off or emergency-stop system, phase rotation relays, undervoltage relays, etc. These parts of the EUT should be tested for immunity according to the standard, and engineering analysis and simulation are used for those modules which are impossible to test for immunity.

E.5 Considerations for voltage dip immunity analysis of very large equipment operation

Dip immunity testing, even of partial systems, is always preferred to simulation and analysis.

However, if engineering analysis and simulation are unavoidable, the following points should be carefully considered.

- The effects of unbalance during the voltage dips, including both magnitude and phase angle unbalance, especially on transformers and motors.
- The possible increase in current on the non-dipped phases during the dip, including its effect on components, connectors, protection devices such as fuses and circuit breakers, etc.
- The possible large increase in current immediately after the dip, including its effect on components, connectors, protection devices such as fuses and circuit breakers, etc.
- The response of safety functions to the voltage dip, including emergency-off and emergency-stop circuits, light curtains, etc.
- The possible effects of the dip on independently-powered sensors, and how those sensors may affect the behaviour of the EUT.
- The response of protective devices, both at the mains terminals of the EUT and at locations within the EUT, to changes in current during and after the dip.
- The response of mains sensing devices, such as phase rotation relays and undervoltage relays, to the voltage dip.
- The response of control relays and contactors, such as relays with 24 V AC coils, to the voltage dip.
- Error signals due to changes in water flow, air pressure, vacuum, etc. caused by brief changes in pump or fan rotation during voltage dips, and how these error signals may affect the EUT behaviour.
- The possible effects of component value variations. For example, electrolytic capacitors are often used as energy storage devices during voltage dips, and may have value tolerances of ±20 % or more.

This is not a complete list. It is offered for guidance only; careful engineering judgement should be applied.

Annex F

(informative)

Interpretation of the rise-time and fall-time requirements during EUT testing

In 2010 an interpretation sheet for IEC 61000-4-11:2004 (second edition) was issued. The contents of this interpretation sheet are similarly applicable to this standard:

Table 4 does not apply to EUT (equipment under test) testing. Table 4 is for generator calibration and design only.

a) With reference to Table 1 and Table 2, there is no requirement in this standard for rise-time and fall-time when testing EUT; therefore, it is not necessary to measure these parameters during tests.

b) 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, 50 Ω or 25 Ω resistor. The requirements of Table 4 do not apply during EUT testing.

Bibliography

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

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