IEC 61000-3-3

Edition 2.0 2008-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electromagnetic compatibility (EMC) –
Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

Compatibilité électromagnétique (CEM) –
Partie 3-3: Limites – Limitation des variations de tension, des fluctuations de tension et du papillotement dans les réseaux publics d'alimentation basse tension, pour les matériels ayant un courant assigné ≤16 A par phase et non soumis à un raccordement conditionnel

IEC 61000-3-3:2008

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CONTENTS

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

FOREWORD

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International Standard IEC 61000-3-3 has been prepared by subcommittee 77A: Low-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This second edition IEC 61000-3-3 cancels and replaces the first edition published in 1994, amendment 1 (2001) and amendment 2 (2005). This edition constitutes a revised edition.

The document 77A/644/FDIS, circulated to the National Committees as amendment 3, led to the publication of the new edition.

The text of this standard is based on the first edition, its amendment 1, amendment 2 and on the following documents:

FDIS	Report on voting
77A/644/FDIS	77A/650/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 amendment and the base publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

INTRODUCTION

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 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 9: Miscellaneous

Each part is further subdivided into sections which are to be published either as International Standards or as Technical Reports.

These standards and reports will be published in chronological order and numbered accordingly.

This part is a Product Family Standard.

The limits in this standard relate to the voltage changes experienced by consumers connected at the interface between the public supply low-voltage network and the equipment user's installation. Consequently, if the actual impedance of the supply at the supply terminals of equipment connected within the equipment user's installation exceeds the test impedance, it is possible that supply disturbance exceeding the limits may occur.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

1 Scope

This part of IEC 61000 is concerned with the limitation of voltage fluctuations and flicker impressed on the public low-voltage system.

It specifies limits of voltage changes which may be produced by an equipment tested under specified conditions and gives guidance on methods of assessment.

This part of IEC 61000 is applicable to electrical and electronic equipment having an input current equal to or less than 16 A per phase, intended to be connected to public low-voltage distribution systems of between 220 V and 250 V line to neutral at 50 Hz, and not subject to conditional connection.

Equipment which does not comply with the limits of this part of IEC 61000 when tested with the reference impedance Z_{ref} of 6.4, and which therefore cannot be declared compliant with this part, may be retested or evaluated to show conformity with IEC 61000-3-11. Part 3-11 is applicable to equipment with rated input current ≤75 A per phase and subject to conditional connection.

The tests according to this part are type tests. Particular test conditions are given in annex A and the test circuit is shown in Figure 1.

NOTE The limits in this part of IEC 61000 are based mainly on the subjective severity of flicker imposed on the light from 230 V/60 W coiled-coil filament lamps by fluctuations of the supply voltage. For systems with nominal voltage less than 220 V line to neutral and/or frequency of 60 Hz, the limits and reference circuit values are under consideration.

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):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC/TR 60725, *Consideration of reference impedances and public supply impedances for use in determining disturbance characteristics of electrical equipment having a rated current ≤75 A per phase*

IEC 60974-1, *Arc welding equipment – Part 1: Welding power sources*

IEC 61000-3-2:2005, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤75 A and subject to conditional connection*

IEC 61000-4-15, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 15: Flickermeter – Functional and design specifications*

3 Definitions

For the purpose of this part of IEC 61000-3, the following definitions apply.

3.1
r.m.s. voltage shape, $U(t)$
the time function of r.m.s. voltage, evaluated as a single value for each successive half period between zero-crossings of the source voltage (see Figure 2)

3.2
voltage change characteristic, $\Delta U(t)$
the time function of the r.m.s. voltage change evaluated as a single value for each successive half period between zero-crossings of the source voltage between time intervals in which the voltage is in a steady-state condition for at least 1 s (see Figure 2)

NOTE Since this characteristic is only used for assessments using calculations, the voltage in the steady-state condition is assumed to be constant within the measurement accuracy (see 6.2).

3.3
maximum voltage change characteristic, ΔU_{max}
the difference between maximum and minimum r.m.s. values of a voltage change characteristic (see Figure 2)

3.4
steady-state voltage change, ΔU_c
the difference between two adjacent steady-state voltages separated by at least one voltage change characteristic (see Figure 2)

NOTE Definitions 3.2 to 3.4 relate to absolute phase-to-neutral voltages. The ratios of these magnitudes to the phase-to-neutral value of the nominal voltage (U_n) of the reference network in Figure 1 are called:

– relative voltage change characteristic: $d(t)$ (definition 3.2);
– maximum relative voltage change: d_{max} (definition 3.3);
– relative steady-state voltage change: d_c (definition 3.4).

These definitions are explained by the example in Figure 3.

3.5
voltage fluctuation

series of changes of r.m.s. voltage evaluated as a single value for each successive half-period between zero-crossings of the source voltage

3.6
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time. [IEV 161-08-13]

3.7
short-term flicker indicator, P_{st}
the flicker severity evaluated over a short period (in minutes); P_{st} = 1 is the conventional threshold of irritability

3.8
long-term flicker indicator, P_{lt}
the flicker severity evaluated over a long period (a few hours) using successive P_{st} values

3.9
flickermeter:
an instrument designed to measure any quantity representative of flicker

NOTE Measurements are normally P_{st} and P_{lt}. [IEV 161-08-14]

3.10
flicker impression time, t_f
value with a time dimension which describes the flicker impression of a voltage change characteristic

3.11
conditional connection
connection of equipment requiring the user's supply at the interface point to have an impedance lower than the reference impedance Z_{ref} in order that the equipment emissions comply with the limits in this part.

NOTE Meeting the voltage change limits may not be the only condition for connection; emission limits for other phenomena such as harmonics, may also have to be satisfied.

3.12
interface point
interface between a public supply network and a user's installation

4 Assessment of voltage changes, voltage fluctuations and flicker

4.1 Assessment of a relative voltage change, "*d*"

The basis for flicker evaluation is the voltage change characteristic at the terminals of the equipment under test, that is the difference ΔU of any two successive values of the phase-to-neutral voltages $U(t_1)$ and $U(t_2)$:

$$\Delta U = U(t_1) - U(t_2) \tag{1}$$

The r.m.s. values $U(t_1)$, $U(t_2)$ of the voltage shall be measured or calculated. When deducing r.m.s. values from oscillographic waveform, account should be taken of any waveform distortion that may be present. The voltage change ΔU is due to the change of the voltage drop across the complex reference impedance $\underline{Z}$, caused by the complex fundamental input current change, $\Delta \underline{I}$, of the equipment under test. ΔI_p and ΔI_q are the active and reactive parts respectively of the current change, $\Delta \underline{I}$.

$$\Delta \underline{I} = \Delta I_p - j \cdot \Delta I_q = \underline{I}(t_1) - \underline{I}(t_2) \tag{2}$$

NOTE 1 I_q is positive for lagging currents and negative for leading currents.

NOTE 2 If the harmonic distortion of the currents $\underline{I}(t_1)$ and $\underline{I}(t_2)$ is less than 10 %, the total r.m.s. value may be applied instead of the r.m.s. values of their fundamental currents.

NOTE 3 For single-phase and symmetrical three-phase equipment the voltage change can, provided X is positive (inductive), be approximated to:

$$\Delta U = \left| \Delta I_p \cdot R + \Delta I_q \cdot X \right| \tag{3}$$

where

ΔI_p and ΔI_q are the active and reactive parts respectively of the current change $\Delta \underline{I}$;

R and X are the elements of the complex reference impedance $\underline{Z}$ (see Figure 1).

The relative voltage change is given by:

$$"d" = \Delta U / U_n \tag{4}$$

4.2 Assessment of the short-term flicker value, P_{st}

The short-term flicker value P_{st} is defined in IEC 61000-4-15.

Table 1 shows alternative methods for evaluating P_{st}, due to voltage fluctuations of different types:

Table 1 – Assessment method

Types of voltage fluctuations	Methods of evaluation P_{st}
All voltage fluctuations (on-line evaluation)	Direct measurement
All voltage fluctuations where $U(t)$ is defined	Simulation Direct measurement
Voltage change characteristics according to Figures 5 to 7 with an occurrence rate less than 1 per second	Analytical method Simulation Direct measurement
Rectangular voltage change at equal intervals	Use of the P_{st} = 1 curve of Figure 4

4.2.1 Flickermeter

All types of voltage fluctuations may be assessed by direct measurement using a flickermeter which complies with the specification given in IEC 61000-4-15, and is connected as described in Clause 6 of this part. This is the reference method for application of the limits.

4.2.2 Simulation method

In the case where the relative voltage change characteristic $d(t)$ is known, P_{st} can be evaluated using a computer simulation.

4.2.3 Analytical method

For voltage change characteristics of the types shown in Figures 5, 6 and 7, the P_{st} value can be evaluated by an analytical method using equations (5) and (6).

NOTE 1 The value of P_{st} obtained using this method is expected to be within ±10 % of the result which would be obtained by direct measurement (reference method).

NOTE 2 This method is not recommended if the time duration between the end of one voltage change and the start of the next is less than 1 s.

4.2.3.1 Description of the analytical method

Each relative voltage change characteristic shall be expressed by a flicker impression time, t_f, in seconds:

$$t_f = 2{,}3\,(F \cdot d_{max})^{3{,}2} \qquad (5)$$

– the maximum relative voltage change d_{max} is expressed as a percentage of the nominal voltage;

– the shape factor, F, is associated with the shape of the voltage change characteristic (see 4.2.3.2).

The sum of the flicker impression times, Σt_f, of all evaluation periods within a total interval of the length T_p, in seconds, is the basis for the P_{st} evaluation. If the total time interval T_p is chosen according to 6.5, it is an "observation period", and:

$$P_{st} = (\Sigma t_f / T_p)^{1/3{,}2} \qquad (6)$$

4.2.3.2 Shape factor

The shape factor, F, converts a relative voltage change characteristic $d(t)$ into a flicker equivalent relative step voltage change ($F \cdot d_{max}$).

NOTE 1 The shape factor, F, is equal to 1,0 for step voltage changes.

NOTE 2 The relative voltage change characteristic may be measured directly (see Figure 1) or calculated from the r.m.s. current of the equipment under test (see equations (1) to (4)).

The relative voltage change characteristic shall be obtained from a histogram of $U(t)$ (see Figure 3).

The shape factor may be deduced from Figures 5, 6 and 7, provided that the relative voltage change characteristic matches a characteristic shown in the Figures. If the characteristics match, proceed as follows:

– find the maximum relative voltage change d_{max} (according to Figure 3); and
– find the time T(ms) appropriate to the voltage change characteristic as shown in Figures 5, 6 and 7 and, using this value, obtain the required shape factor, F.

NOTE 3 Extrapolation outside the range of the Figures may lead to unacceptable errors.

4.2.4 Use of P_{st} = 1 curve

In the case of rectangular voltage changes of the same amplitude "d" separated by equal time intervals, the curve of Figure 4 may be used to deduce the amplitude corresponding to P_{st} = 1 for a particular rate of repetition; this amplitude is called d_{lim}. The P_{st} value corresponding to the voltage change "d" is then given by $P_{st} = d/d_{lim}$.

4.3 Assessment of long-term flicker value, P_{lt}

The long-term flicker value P_{lt} is defined in IEC 61000-4-15 and shall be applied with the value of N = 12 (see 6.5).

It is generally necessary to assess the value of P_{lt} for equipment which is normally operated for more than 30 min at a time.

5 Limits

The limits shall be applicable to voltage fluctuations and flicker at the supply terminals of the equipment under test, measured or calculated according to Clause 4 under test conditions described in Clause 6 and Annex A. Tests made to prove compliance with the limits are considered to be type tests.

The following limits apply:

– the value of P_{st} shall not be greater than 1,0;
– the value of P_{lt} shall not be greater than 0,65;
– the value of $d(t)$ during a voltage change shall not exceed 3,3 % for more than 500 ms;
– the relative steady-state voltage change, d_c, shall not exceed 3,3 %;
– the maximum relative voltage change d_{max}, shall not exceed
  a) 4 % without additional conditions;
  b) 6 % for equipment which is:
    – switched manually, or
    – switched automatically more frequently than twice per day, and also has either a delayed restart (the delay being not less than a few tens of seconds), or manual restart, after a power supply interruption.

NOTE The cycling frequency will be further limited by the P_{st} and P_{lt} limit. For example: a d_{max} of 6 % producing a rectangular voltage change characteristic twice per hour will give a P_{lt} of about 0,65.

c) 7 % for equipment which is

- attended whilst in use (for example: hair dryers, vacuum cleaners, kitchen equipment such as mixers, garden equipment such as lawn mowers, portable tools such as electric drills), or
- switched on automatically, or is intended to be switched on manually, no more than twice per day, and also has either a delayed restart (the delay being not less than a few tens of seconds) or manual restart, after a power supply interruption.

In the case of equipment having several separately controlled circuits in accordance with 6.6, limits b) and c) shall apply only if there is delayed or manual restart after a power supply interruption; for all equipment with automatic switching which is energised immediately on restoration of supply after a power supply interruption, limits a) shall apply; for all equipment with manual switching, limits b) or c) shall apply depending on the rate of switching.

P_{st} and P_{lt} requirements shall not be applied to voltage changes caused by manual switching.

The limits shall not be applied to voltage changes associated with emergency switching or emergency interruptions.

6 Test conditions

6.1 General

Tests need not be made on equipment which is unlikely to produce significant voltage fluctuations or flicker.

It may be necessary to determine, by examination of the circuit diagram and specification of the equipment and by a short functional test, whether significant voltage fluctuations are likely to be produced.

For voltage changes caused by manual switching, equipment is deemed to comply without further testing if the maximum r.m.s. input current (including inrush current) evaluated over each 10 ms half-period between zero-crossings does not exceed 20 A, and the supply current after inrush is within a variation band of 1,5 A.

If measurement methods are used, the maximum relative voltage change d_{max} caused by manual switching shall be measured in accordance with Annex B.

Tests to prove the compliance of the equipment with the limits shall be made using the test circuit in Figure 1.

The test circuit consists of:

- the test supply voltage (see 6.3);
- the reference impedance (see 6.4);
- the equipment under test (see Annex A);
- if necessary, a flickermeter (see IEC 61000-4-15).

The relative voltage change $d(t)$ may be measured directly or derived from the r.m.s. current as described in 4.1. To determine the P_{st} value of the equipment under test, one of the methods described in 4.2 shall be used. In case of doubt, the P_{st} shall be measured using the reference method with a flickermeter.

NOTE If balanced multiphase equipment is tested, it is acceptable to measure only one of the three line-to-neutral voltages.

6.2 Measurement accuracy

The magnitude of the current shall be measured with an accuracy of ±1 % or better. If instead of active and reactive current the phase angle is used, its error shall not exceed ±2°.

The relative voltage change "*d*" shall be determined with a total accuracy better than ±8 % with reference to the maximum value d_{max}. The total impedance of the circuit, excluding the appliance under test, but including the internal impedance of the supply source, shall be equal to the reference impedance. The stability and tolerance of this total impedance shall be adequate to ensure that the overall accuracy of ±8 % is achieved during the whole assessment procedure.

NOTE The following method is not recommended where the measured values are close to the limits.

When the source impedance is not well defined, for example where the source impedance is subject to unpredictable variations, an impedance having resistance and inductance equal to the reference impedance may be connected between the supply and the terminals of the equipment under test. Measurements can then be made of the voltages at the source side of the reference impedance and at the equipment terminals. In that case, the maximum relative voltage change, d_{max}, measured at the supply terminals shall be less than 20 % of the maximum value d_{max} measured at the equipment terminals.

6.3 Test supply voltage

The test supply voltage (open-circuit voltage) shall be the rated voltage of the equipment. If a voltage range is stipulated for the equipment, the test voltage shall be 230 V single-phase or 400 V three-phase. The test voltage shall be maintained within ±2 % of the nominal value. The frequency shall be 50 Hz ± 0,5 %.

The percentage total harmonic distortion of the supply voltage shall be less than 3 %.

Fluctuations of the test supply voltage during a test may be neglected if the P_{st} value is less than 0,4. This condition shall be verified before and after each test.

6.4 Reference impedance

For equipment under test the reference impedance, $\underline{Z}_{ref}$, according to IEC 60725, is a conventional impedance used in the calculation and measurement of the relative voltage change "*d*", and the P_{st} and P_{lt} values.

The impedance values of the various elements are given in Figure 1.

6.5 Observation period

The observation period, T_p, for the assessment of flicker values by flicker measurement, flicker simulation, or analytical method shall be:

- for P_{st}, T_p = 10 min;
- for P_{lt}, T_p = 2 h.

The observation period shall include that part of the whole operation cycle in which the equipment under test produces the most unfavourable sequence of voltage changes.

For the assessment of P_{st}, the cycle of operation shall be repeated continuously, unless stated otherwise in Annex A. The minimum time to restart the equipment shall be included in this observation period when testing equipment that stops automatically at the end of a cycle of operation which lasts for less than the observation period.