IEC 61000-3-3

Edition 3.0 2013-05

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 61000-3-3:2013

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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: EMC – Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This standard forms part 3-3 of IEC 61000 series of standards. It has the status of a product family standard.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) This edition takes account of the changes made in IEC 61000-4-15:2010.

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

FDIS	Report on voting
77A/809/FDIS	77A/816/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.

A list of all parts in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability 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- withdrawn,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.

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 1 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 could occur.

NOTE 2 The limits in this standard 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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, *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 61000-4-15:2010, *Electromagnetic compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

[SOURCE: IEC 60050-161:1990, 161-08-13]

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

Note 1 to entry: For detailed information about the evaluation of a voltage change characteristic and the definition of a steady state condition see Annex C and IEC 61000-4-15:2010.

3.3
d_c
maximum steady state voltage change during an observation period

Note 1 to entry: For detailed information about the calculation of d_c see Annex C and IEC 61000-4-15:2010.

3.4
d_{max}
maximum absolute voltage change during an observation period

Note 1 to entry: For detailed information about the calculation of d_{max} see Annex C and IEC 61000-4-15:2010.

3.5
T_{max}
maximum time duration during the observation period that the voltage deviation $d(t)$ exceeds the limit for d_c

Note 1 to entry: During a voltage change characteristic the time duration T_{max} is accumulated until a new steady state condition is established.

Note 2 to entry: The T_{max} limit evaluation in this standard is generally intended to evaluate the inrush current pattern of the equipment under test. Thus, as soon as a new steady state condition is established, the T_{max} evaluation is ended. When a new voltage change occurs that exceeds the limit for d_c, a new T_{max} evaluation is started. The maximum duration that $d(t)$ exceeds the limit for d_c for any of the individual T_{max} evaluations during the observation period, is used for the comparison against the T_{max} limit, and is reported for the test.

3.6
nominal test voltage
U_n
nominal test voltage used to calculate percentages for the various directly measured parameters

Note 1 to entry: If no steady state condition is achieved during the observation period, U_n is used for the calculation of d_{max} and T_{max}.

Note 2 to entry: U_n is not necessarily equal to the nominal voltage of the public supply.

3.7
***P*st**
short-term flicker severity

Note 1 to entry: If not specified differently, the P_{st} evaluation time is 10 minutes. For the purpose of power quality surveys and studies, other time intervals may be used, and have to be defined in the index. For example a 1 minute interval should be written as $P_{st,1min}$.

3.8
***P*lt**
long-term flicker severity

$$P_{lt} = \sqrt[3]{\frac{\sum_{i=1}^{N} P_{st,i}^3}{N}}$$

where $P_{st,i}$ (i = 1, 2, 3, ...) are consecutive readings of the short-term severity P_{st}

Note 1 to entry: Unless otherwise specified, P_{lt} is calculated over discrete T_{long} periods. Each time a T_{long} period has expired, a new P_{lt} calculation is started.

3.9
flickermeter
instrument designed to measure any quantity representative of flicker

Note 1 to entry: Measurements are normally P_{st} and P_{lt} and may also include the directly measured parameters specified in 3.2 to 3.5.

[SOURCE: IEC 60050-161:1990, 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
shape factor
F
value derived from the type of voltage fluctuation, such as a step, double step, or ramp pattern

Note 1 to entry: The shape factor is mainly needed when the analytical method is used to calculate P_{st}.

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

3.13
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 1 to entry: 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.

4 Assessment of voltage changes, voltage fluctuations and flicker

4.1 Assessment of a relative voltage change, $d(t)$

The basis for flicker evaluation is the voltage change characteristic at the terminals of the equipment under test, that is the difference $\Delta U_{hp}(t)$ of any two successive values of the phase-to-neutral voltages $U_{hp}(t_1)$ and $U_{hp}(t_2)$:

$$\Delta U_{hp}(t) = U_{hp}(t_1) - U_{hp}(t_2) \quad (1)$$

NOTE 1 See Annex C for relevant definitions that are taken from IEC 61000-4-15:2010.

The r.m.s. values $U_{hp}(t_1)$, $U_{hp}(t_2)$ of the voltage shall be measured or calculated. When deducing r.m.s. values from oscillographic waveforms, account should be taken of any waveform distortion that may be present.

The voltage change at the EUT terminals, 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, $\Delta \underline{I}$.

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

NOTE 2 I_q is positive for lagging currents and negative for leading currents.

NOTE 3 If the harmonic distortion of the currents $I(t_1)$ and $I(t_2)$ is less than 10 %, the total r.m.s. value can be applied instead of the r.m.s. values of their fundamental currents, taking account of the phase angles of the fundamental currents.

NOTE 4 For single-phase and symmetrical three-phase equipment the voltage change can be, provided X is positive (inductive), approximated to:

$$\Delta U_{hp} = \left| \Delta I_p R + \Delta I_q X \right| \quad (3)$$

where ΔI_p and ΔI_q are the active and reactive parts respectively of the current change $\Delta \underline{I}$ and R and X are the elements of the complex reference impedance Z (see Figure 1).

The relative voltage change is given by:

$$d = \Delta U_{hp} / U_n \quad (4)$$

The $d_{max,i}$ evaluation ends as soon as a new steady state condition is established, or at the end of the observation period. The polarity of change(s) may be indicated as follows: if the maximum voltage deviation is observed during a reduction in voltage with respect to the previous $d_{end,i}$ the resulting $d_{max,i}$ value is positive; if the maximum voltage deviation is observed during a voltage increase with respect to the previous $d_{end,i}$ the resulting $d_{max,i}$ value is negative.

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

4.2.1 General

Table 1 shows alternative methods for evaluating P_{st}, due to voltage fluctuations of different types; in all cases direct measurement (with a flickermeter) is acceptable:

Table 1 – Assessment method

Types of voltage fluctuations	Method for evaluating P_{st}
All voltage fluctuations (on-line evaluation)	Flickermeter
All voltage fluctuations where $U(t)$ is known	Simulation
Voltage change characteristics according to Figures 3 to 5 with an occurrence rate less than 1 per second	Analytical
Rectangular voltage change at equal intervals	Use of the P_{st} = 1 curve of Figure 2

4.2.2 Flickermeter

All types of voltage fluctuations may be assessed by direct measurement using a flickermeter which complies with the specification given in IEC 61000-4-15:2010, and is connected as described in this standard. This is the reference method for application of the limits.

4.2.3 Simulation method

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

4.2.4 Analytical method

4.2.4.1 General

For voltage change characteristics of the types shown in Figures 3, 4 and 5, 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 used if the time duration between the end of one voltage change and the start of the next is less than 1 s.

4.2.4.2 Description of the analytical method

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

$$t_f = 2,3\ (Fd_{max})^{3,2} \tag{5}$$

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

– the shape factor, F, is associated with the shape of the voltage change characteristic (see 4.2.4.3).

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:

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

4.2.4.3 Shape factor

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

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

NOTE 2 The relative voltage change characteristic can 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 time progression of $U_{hp}(t)$ (see Figure C.1).

The shape factor may be deduced from Figures 3, 4 and 5, provided that the relative voltage change characteristic matches a characteristic shown in these figures. If the characteristics match, proceed as follows:

– find the maximum relative voltage change d_{max}; and
– find the time T (in ms) appropriate to the voltage change characteristic as shown in Figures 3, 4 and 5 and, using this value, obtain the required shape factor, F.

NOTE 3 Extrapolation outside the range of the figures would lead to unacceptable errors.

4.2.5 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 2 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} 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;
- T_{max}, the accumulated time value of $d(t)$ with a deviation exceeding 3,3 % during a single voltage change at the EUT terminals, shall not exceed 500 ms;
- the maximum 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 is further limited by the P_{st} and P_{lt} limits. For example: a d_{max} of 6 % producing a rectangular voltage change characteristic twice per hour gives 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 energized 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. Where it is considered necessary to conduct tests, the equipment shall comply with all limits in Clause 5 for the tests described in Annex A unless there are specific exclusions for a particular type of equipment.

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 61000-4-15:2010).

The relative voltage change $d_{hp}(t)$ 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.