

Electromagnetic compatibility (EMC) —

Part 4: Testing and measurement techniques —

Section 7: General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto

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National foreword

This British Standard has been prepared under the direction of the General Electrotechnical Standards Policy Committee and is the English language version of EN 61000-4-7:1993 *Electromagnetic compatibility (EMC)*.

Part 4: Testing and measurement techniques — Section 7: General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 1000-4-7:1991 published by the International Electrotechnical Commission (IEC).

IEC 1000 will be published in separate Parts in accordance with 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 9: Miscellaneous.*

Each Part will be subdivided into Sections each of which may be published as either a standard or a technical report.

This standard is complementary to IEC 555-2:1982 with Amendment No. 1:1985 which have been adopted by CENELEC with common modifications as EN 60555-2 and published as BS 5406-2:1988.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 22, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

**Electromagnetic compatibility (EMC)
Part 4: Testing and measurement techniques
Section 7: General guide on harmonics and
interharmonics measurements and instrumentation, for
power supply systems and equipment connected thereto**

(IEC 1000-4-7:1991)

Compatibilité électromagnétique (CEM)
Partie 4: Techniques d'essai et de mesure
Section 7: Guide général relatif aux mesures
d'harmoniques et d'interharmoniques, ainsi
qu'à l'appareillage de mesure, applicable aux
réseaux d'alimentation et aux appareils qui y
sont raccordés
(CEI 1000-4-7:1991)

Elektromagnetische Verträglichkeit (EMV)
Teil 4: Prüf- und Meßverfahren
Hauptabschnitt 7: Allgemeiner Leitfaden für
Verfahren und Geräte zur Messung von
Oberschwingungen und
Zwischenharmonischen in
Stromversorgungsnetzen und angeschlossenen
Geräten
(IEC 1000-4-7:1991)

This European Standard was approved by CENELEC on 1992-12-09. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 1000-4-7:1991 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 61000-4-7 on 9 December 1992.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1993-12-01
- latest date of withdrawal of conflicting national standards (dow) 1993-12-01

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given only for information. In this standard, Annex A is informative and Annex ZA is normative.

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1 Scope

This guide is applicable to instrumentation intended for measuring voltage or current components with frequencies in the range of d.c. to 2 500 Hz which are superimposed on the voltage or current at the power supply frequency.

This guide is also applicable to measurement instrumentation intended for testing individual items of equipment in accordance with emission limits given in standards (e.g. harmonic current limits as given in IEC 555-2) as well as for the measurement of harmonic voltages and currents in actual supply systems. The survey of harmonics in the power supply systems is of particular concern.

The test procedure for measurements and test conditions for emission testing are not dealt with in this guide; these requirements are included in the particular standards.

Harmonics of the supply frequency are of special concern but components at other frequencies (interharmonic components) may also have to be measured.

Frequency-domain and time-domain instrumentation are both considered in this guide.

Tentative recommendations are also given for the statistical analysis of harmonic measurements in the supply in order to make the comparison of results easier.

For fluctuating and rapidly changing harmonics, a distinction is made between the measurement process itself with its relatively small time constant, and the evaluation process which handles the measurement data in a defined manner in order to compare the results with stated limits, acceptance or reference values.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(161):1990, *International Electrotechnical Vocabulary (IEV), Chapter 161: Electromagnetic compatibility*.

IEC 348:1978, *Safety requirements for electronic measuring apparatus*.

IEC 555-1:1982, *Disturbances in supply systems caused by household appliances and similar electrical equipment — Part 1: Definitions*.

IEC 555-2:1982, *Part 2: Harmonics. Disturbances in supply systems caused by household appliances and similar electrical equipment*¹⁾.

IEC 801-2:1984, *Electromagnetic compatibility for industrial-process measurement and control equipment — Part 2: Electrostatic discharge*.

3 Definitions, symbols and indices

3.1

voltage U_m

component at frequency f_m of the supply voltage

3.2

current I_m

component at frequency f_m of the supply current

NOTE The expressions U_m (or I_m) and f_m are replaced by U_n (or I_n) and f_n when harmonic quantities of order n related to the power supply frequency are considered.

3.3 definitions related to harmonics: Refer to IEC 50(161) and IEC 555-1

Notations: The following notations are used in the present guide for the Fourier series development because it is easier to measure phase angles by observations of the zero crossings:

$$f(\omega t) = c_0 + \sum_{n=1}^{\infty} c_n \sin(n\omega_1 t + \varphi_n)$$

$$\underline{c}_n = b_n + ja_n = c_n e^{j\varphi_n}; \quad \varphi_n = \arctan\left(\frac{a_n}{b_n}\right)$$

$$b_n = \frac{1}{\pi} \int_0^{2\pi} f(\omega t) \sin(n\omega_1 t) d(\omega t)$$

$$a_n = \frac{1}{\pi} \int_0^{2\pi} f(\omega t) \cos(n\omega_1 t) d(\omega t)$$

$$c_0 = \frac{1}{2\pi} \int_0^{2\pi} f(\omega t) d(\omega t)$$

where:

ω_1 is the angular frequency of the fundamental ($\omega_1 = 2\pi f_1$);

$\underline{c}_n$ is the complex amplitude of the component with frequency $f_n = nf_1$;

c_0 is the d.c. component.

NOTE Strictly speaking these definitions apply to steady-state signals only.

¹⁾ Under revision.

3.4 interharmonics

components at frequencies located between the harmonics of the supply frequency

3.5 frequency-domain instrumentation

instrumentation which performs the analysis of signals by using analogue filtering technique

3.6 time-domain instrumentation

instrumentation which performs the analysis by time sampling of the signals and subsequent numerical handling of the sampled data. Fast-Fourier-transform (FFT) is the most widely used computation algorithm for harmonic analysis

3.7 Symbols

a	imaginary coefficient (amplitude) of the Fourier series
b	real coefficient (amplitude) of the Fourier series
c	complex coefficient of the Fourier series
d	distortion factor
f	frequency; function
f_1	fundamental frequency
j	$\sqrt{-1}$
p	percentage of cumulated probability function
t	running time
x	sampled value
B	bandwidth
C	r.m.s. value of the spectral line
D	weighted distortion factor
I	current (r.m.s. value)
M	integer number; number of samples within the window width
PCC	point of common coupling
T	time interval
T_1	fundamental period
T_w	NT_1 window width
U	voltage (r.m.s. value)
ω	angular frequency
φ	phase angle

3.8 Indices

cap	capacitive
ind	inductive
i	running integer number
k	running integer number
m	measured value; spectral content of order m (not necessarily integer)
n	harmonic order: running number (integer)
r	rated value
s	sampled; synchronized
D	day
L	long
N	nominal value
Sh	short
VS	very short
Wk	week

4 General classification of instrumentation

The instrumentation may be differentiated according to the characteristics of the signal U_m or I_m to be measured, according to the accuracy classes of instrumentation and according to the type of measurement (voltage, current etc.) required. Recommendations to cover these various needs are given separately in this guide.

The instrumentation may be constructed either to cover a particular need and application (e.g. steady-state harmonics on the supply voltage) or to comply with the requirements for several cases (e.g. voltage and current measurements, harmonics and interharmonics).

4.1 Characteristics of the signal to be measured

The requirements for different types of instrumentation intended to cover the following needs are considered:

- quasi-stationary (slowly varying) harmonics;
- fluctuating harmonics;
- rapidly changing harmonics (or very short bursts of harmonics);
- interharmonics and other spurious components.

Methods are given in this guide for these four different cases but it is impossible to define precisely the borderline between the first three categories. The application documents will indicate the most appropriate method for satisfying the EMC required. Examples are given below.

- In case a) it is recognized that a continuous analysis (without time gap between successive measurements) is not necessary. Applications are for example:
 - 1) the measurement of constant harmonic currents (as produced by TV-receivers, light dimmers),
 - 2) the long-term survey of harmonics on the supply system, when instantaneous effects of harmonics are not considered important.
- In the intermediate case b), a continuous real-time analysis is required. One application of that type is the measurement of fluctuating harmonic currents due to motor reversals, speed change, etc. in household appliances with electronic phase control and regulation. Another example would be supply voltage monitoring in industrial systems with e.g. rolling mills.
- In case c), continuous real-time measurement is absolutely necessary and very precise requirements are necessary to get reproducible results. Such instrumentation may become necessary in the near future to analyse rapidly changing harmonics or very short bursts of harmonics (the changes may occur over 1 s or much less) which may possibly be harmful, for example, to telecontrol-receiver operation on the supply.

Interharmonics and other spurious components are considered separately. (See 10.4.)

4.2 Accuracy classes of instrumentation

Two classes of accuracy (A and B) for voltage and current harmonic analysis are considered, as simple and low-cost instruments may deserve consideration. For emission tests according to IEC 555-2 the upper class A is required.

4.3 Types of measurement

Recommendations for voltage and current harmonic measurements are given separately. Special cases of measurement (phase angle of harmonics, total harmonic distortion, weighted harmonic distortion, symmetrical components measurements, etc.) are also considered.

5 Common requirements for all types of instrumentation

The following requirements are applicable to all types of Instrumentation, whether operating in frequency-domain or in time-domain. They are valid for steady-state, fluctuating or very fast changing harmonics and interharmonics.

5.1 Requirements for input circuits

5.1.1 Voltage input circuit

The input circuit of the measuring instrument shall be adapted to the nominal voltage and frequency of the supply voltage to be analyzed and shall keep its characteristics and accuracy unchanged up to 1,2 times this nominal voltage. A crest factor of at least 1,5 is considered sufficient for measurements except for highly distorting loads in industrial networks when a crest factor of at least 2 may be necessary. An overload indication is required in any case.

It is suggested that stressing the input for 1 s by an a.c. voltage of four times the input voltage setting or $1 \text{ kV}_{\text{rms}}$ whichever is less, should not lead to any damage in the instrument.

Other requirements: see clause 11.

To permit a relatively universal use of the instrument for most supply systems, it may be advisable for the input circuit to be designed for the following nominal voltages:

U_N : 115, 230, 400 V.

NOTE 1 The first range 115 V may also be used in association with external voltage transformers. Other additional ranges may also be useful for that purpose (e.g. 100 V , $100 \text{ V}/\sqrt{3}$, $110 \text{ V}/\sqrt{3}$).

NOTE 2 Inputs with higher sensitivity (0,1; 1; 10 V) are useful for operation with external transducers (see for example 5.1.2). A crest factor of at least 2 may be necessary.

The power absorption of the input-circuit shall not exceed 3 VA. If high sensitivity inputs ($\leq 50 \text{ V}$) are provided, their input resistance shall be at least $10 \text{ k}\Omega/\text{V}$.

Care should be taken that the high value of the fundamental (supply frequency) as compared to the harmonics to be measured does not produce overload causing damage or harmful intermodulation error signals in the input stages of the instrument; such errors shall be well below the stated accuracy.