

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

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

**Compatibilité électromagnétique (CEM) –  
Partie 4-7: Techniques d'essai et de mesure – 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**



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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTROMAGNETIC COMPATIBILITY (EMC) –**Part 4-7: Testing and measurement techniques –  
General guide on harmonics and interharmonics measurements and  
instrumentation, for power supply systems and  
equipment connected thereto**

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International Standard IEC 61000-4-7 has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This consolidated version of IEC 61000-4-7 consists of the second edition (2002) [documents 77A/382/FDIS and 77A/387/RVD], its amendment 1 (2008) [documents 77A/645/FDIS and 77A/651/RVD] and its corrigendum of July 2004.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 2.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

This standard forms part 4-7 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

Annexes A, B and C are for information only.

The committee has decided that the contents of the base publication and its amendments 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- withdrawn,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.

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## INTRODUCTION

IEC 61000 is published in separate parts, according to the following structure:

### **Part 1: General**

General considerations (introduction, fundamental principles)  
Definitions, terminology

### **Part 2: Environment**

Description of the environment  
Classification of the environment  
Compatibility levels

### **Part 3: Limits**

Emission limits  
Immunity limits (in so far as they do not fall under the responsibility of the product committees)

### **Part 4: Testing and measurement techniques**

Measurement techniques  
Testing techniques

### **Part 5: Installation and mitigation guidelines**

Installation guidelines  
Mitigation methods and devices

### **Part 6: Generic standards**

### **Part 9: Miscellaneous**

Each part is further subdivided into several parts, published either as International Standards or as technical specifications or technical reports, some of which have already been published as sections. Other will be published with the part number followed by a dash and a second number identifying the subdivision (example: 61000-6-1).

These publications will be published in chronological order and numbered accordingly.

This part is an International Standard for the measurement of harmonic currents and voltages in power supply systems and harmonic currents emitted by equipment. It also specifies the performance of a standard measuring instrument.

## ELECTROMAGNETIC COMPATIBILITY (EMC) –

### Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto

#### 1 Scope

This part of IEC 61000 is applicable to instrumentation intended for measuring spectral components in the frequency range up to 9 kHz which are superimposed on the fundamental of the power supply systems at 50 Hz and 60 Hz. For practical considerations, this standard distinguishes between harmonics, interharmonics and other components above the harmonic frequency range, up to 9 kHz.

This standard defines the measurement instrumentation intended for testing individual items of equipment in accordance with emission limits given in certain standards (for example, harmonic current limits as given in IEC 61000-3-2) as well as for the measurement of harmonic currents and voltages in actual supply systems. Instrumentation for measurements above the harmonic frequency range, up to 9 kHz is tentatively defined (see Annex B).

NOTE 1 This document deals in detail with instruments based on the discrete Fourier transform.

NOTE 2 The description of the functions and structure of the measuring instruments in this standard is very explicit and meant to be taken literally. This is due to the necessity of having reference instruments with reproducible results irrespective of the characteristics of the input signals.

NOTE 3 The instrument is defined to accommodate measurements of harmonics up to the 50th order.

#### 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 60038, *IEC standard voltages*

IEC 60050-161, *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*

IEC 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

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

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current  $> 16$  A and  $\leq 75$  A per phase*

### 3 Definitions, symbols and indices

For the purposes of this part of IEC 61000, the definitions given in IEC 60050-161 (IEV) and the following, apply.

#### 3.1 Definitions related to frequency analysis

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:

$$f(t) = c_0 + \sum_{k=1}^{\infty} c_k \sin\left(\frac{k}{N} \omega_1 t + \varphi_k\right) \quad (1)$$

$$\text{with: } \begin{cases} c_k = |b_k + ja_k| = \sqrt{a_k^2 + b_k^2} \\ Y_{C,k} = \frac{c_k}{\sqrt{2}} \\ \varphi_k = \pi + \arctan\left(\frac{a_k}{b_k}\right) \text{ if } b_k < 0 & \varphi_k = \arctan\left(\frac{a_k}{b_k}\right) \text{ if } b_k > 0 \\ \varphi_k = \frac{\pi}{2} \text{ if } b_k = 0 \text{ and } a_k > 0 & \varphi_k = -\frac{\pi}{2} \text{ if } b_k = 0 \text{ and } a_k < 0 \\ \varphi_k = 0 \text{ if } |b_k| \leq \varepsilon \text{ and } |a_k| \leq \varepsilon, \end{cases} \quad (2)$$

with  $\varepsilon = 0,05 \% U_{\text{nom}}$  and  $\varepsilon = 0,15 \% I_{\text{nom}}$   
or  $\varepsilon = 0,15 \% U_{\text{nom}}$  and  $\varepsilon = 0,5 \% I_{\text{nom}}$   
respectively, see table 1 in IEC 61000-4-7

$$\text{and: } \begin{cases} b_k = \frac{2}{T_N} \int_0^{T_N} f(t) \times \sin\left(\frac{k}{N} \omega_1 t\right) dt \\ a_k = \frac{2}{T_N} \int_0^{T_N} f(t) \times \cos\left(\frac{k}{N} \omega_1 t\right) dt \\ c_0 = \frac{1}{T_N} \int_0^{T_N} f(t) dt \end{cases} \quad (3)$$

NOTE 1 The above definition setting  $\varphi_k$  to zero for the cases where  $b_k$  and  $a_k$  have very small values provides guidance to instrument manufacturers, as phase measurements of very small amplitudes may result in very large deviations, hence there is no requirement to measure phase for such small signals.

$\omega_1$  is the angular frequency of the fundamental ( $\omega_1 = 2\pi f_{H,1}$ );

$T_N$  is the width (or duration) of the time window; the time window is that time span of a time function over which the Fourier transform is performed;

$c_0$  is the d.c. component;

- $c_k$  is the amplitude of the component with frequency  $f_{C,k} = \frac{k}{N} f_{H,1}$ ;
- $Y_{C,k}$  is the r.m.s. value of component  $c_k$ ;
- $f_{H,1}$  is the fundamental frequency of the power system;
- $k$  is the ordinal number (order of the spectral component) related to the frequency resolution  $\left(f_{C,1} = \frac{1}{T_N}\right)$ ;
- $N$  is the number of fundamental periods within the window width;
- $\varphi_k$  is the phase angle of spectral line  $k$ .

NOTE 2 Strictly speaking these definitions apply to steady-state signals only. The Fourier series is actually in most cases performed digitally, i.e. as a Discrete Fourier Transform DFT, or a variant thereof, being the FFT.

The analogue signal  $f(t)$  which has to be analyzed is sampled, A/D-converted and stored. Each group of  $M$  samples forms a time window on which DFT is performed. According to the principles of Fourier series expansion, the window width  $T_N$  determines the frequency resolution  $f_{C,1} = 1/T_N$  (i.e. the frequency separation of the spectral components) for the analysis. Therefore the window width  $T_N$  must be an integer multiple  $N$  of the fundamental period  $T_1$  of the system voltage:  $T_N = N \times T_1$ . The sampling rate is in this case  $f_s = M/(NT_1)$  (where  $M$  = number of samples within  $T_N$ ).

Before DFT-processing, the samples in the time window are often weighted by multiplying them with a special symmetrical function ('windowing function'). However, for periodic signals and synchronous sampling it is preferable to use a rectangular weighting window which multiplies each sample by unity.

The DFT-processor yields the orthogonal Fourier-coefficients  $a_k$  and  $b_k$  of the corresponding spectral-component frequencies  $f_{C,k} = k/T_N$ ,  $k = 0, 1, 2 \dots M-1$ . However, only  $k$  values up to and including half of the maximum value are useful, the other half just duplicates them.

Under synchronized conditions, the component of harmonic order  $h$  related to the fundamental frequency  $f_{H,1}$  appears as the spectral component of order  $k$ , where  $k = hN$ .

NOTE 3 The Fast Fourier Transform FFT is a special algorithm allowing short computation times. It requires that the number of samples  $M$  be an integer power of 2,  $M = 2^i$ , with  $i \geq 10$  for example.

NOTE 4 The symbol  $Y$  is replaced, as required by the symbol  $I$  for currents, by the symbol  $U$  for voltages. Index  $C$  qualifies the variable as spectral component.

## 3.2 Definitions related to harmonics

### 3.2.1 harmonic frequency

$f_{H,h}$   
frequency which is an integer multiple of the fundamental frequency of the power system ( $f_{H,h} = h \times f_{H,1}$ )

NOTE The harmonic frequency  $f_{H,h}$  is identical with the component frequency  $f_{C,k}$  with  $k = h \times N$ .

### 3.2.2 harmonic order

$h$

(integer) ratio of a harmonic frequency to the fundamental frequency of the power system. In connection with the analysis using DFT and synchronisation between  $f_{H,1}$  and  $f_s$  (sampling rate), the harmonic order  $h$  corresponds to the spectral component  $k = h \times N$  ( $k$  = number of the spectral component,  $N$  = number of periods of the fundamental frequency in time window  $T_N$ )

### 3.2.3 r.m.s. value of a harmonic component

$Y_{H,h}$

r.m.s. value of one of the components having a harmonic frequency in the analysis of a non-sinusoidal waveform

For brevity, such a component may be referred to simply as a "harmonic"

NOTE 1 The harmonic component  $Y_{H,h}$  is identical with the spectral component  $Y_{C,k}$  with  $k = h \times N$ ; ( $Y_{H,h} = Y_{C,h \times N}$ ). The symbol  $Y$  is replaced, as required by the symbol  $I$  for currents, by the symbol  $U$  for voltages. The index  $H$  qualifies the variable  $I$  or  $U$  as harmonic.

NOTE 2 For the purposes of this standard, the time window has a width of  $N = 10$  (50 Hz systems) or  $N = 12$  (60 Hz system) fundamental periods, i.e. approximately 200 ms (see 4.4.1). This yields  $Y_{H,h} = Y_{C,10 \times h}$  (50 Hz systems) and  $Y_{H,h} = Y_{C,12 \times h}$  (60 Hz systems).

### 3.2.4

#### r.m.s. value of a harmonic group

$Y_{g,h}$

square root of the sum of the squares of the r.m.s. value of a harmonic and the spectral components adjacent to it within the time window, thus summing the energy contents of the neighbouring components with that of the harmonic proper. See also equation 8 and Figure 4. The harmonic order is given by the harmonic considered.

NOTE The symbol  $Y$  is replaced, as required by the symbol  $I$  for currents, by the symbol  $U$  for voltages.

### 3.2.5

#### r.m.s. value of a harmonic subgroup

$Y_{sg,h}$

square root of the sum of the squares of the r.m.s. value of a harmonic and the two spectral components immediately adjacent to it. For the purpose of including the effect of voltage fluctuation during voltage surveys, a subgroup of output components of the DFT is obtained by summing the energy contents of the frequency components directly adjacent to a harmonic with that of the harmonic proper. (See also equation 9 and Figure 6.) The harmonic order is given by the harmonic considered

NOTE The symbol  $Y$  is replaced, as required by the symbol  $I$  for currents, by the symbol  $U$  for voltages.

## 3.3 Definitions related to distortion factors

### 3.3.1

#### total harmonic distortion

THD

$THD_Y$  (symbol)

ratio of the r.m.s. value of the sum of all the harmonic components ( $Y_{H,h}$ ) up to a specified order ( $h_{\max}$ ) to the r.m.s. value of the fundamental component ( $Y_{H,1}$ ):

$$THD_Y = \sqrt{\sum_{h=2}^{h_{\max}} \left( \frac{Y_{H,h}}{Y_{H,1}} \right)^2} \quad (4)$$

NOTE 1 The symbol  $Y$  is replaced, as required, by the symbol  $I$  for currents or by the symbol  $U$  for voltages.

NOTE 2 The value of  $h_{\max}$  is 40 if no other value is defined in a standard concerned with limits (IEC 61000-3 series).

### 3.3.2

#### group total harmonic distortion

THDG

$THDG_Y$  (symbol)

ratio of the r.m.s. value of the harmonic groups ( $Y_{g,h}$ ) to the r.m.s. value of the group associated with the fundamental ( $Y_{g,1}$ ):

$$THDG_Y = \sqrt{\sum_{h=h_{\min}}^{h_{\max}} \left( \frac{Y_{g,h}}{Y_{g,1}} \right)^2} \quad \text{where } h_{\min} \geq 2 \quad (5)$$

NOTE 1 The symbol  $Y$  is replaced, as required, by the symbol  $I$  for currents or by the symbol  $U$  for voltages.

NOTE 2 The value of  $h_{\min}$  is 2 and that of  $h_{\max}$  is 40 if no other values are defined in a standard concerned with limits (for example IEC 61000-3 series).

**3.3.3****THDS****subgroup total harmonic distortion** **$THDS_Y$**  (symbol)

ratio of the r.m.s. value of the harmonic sub-groups ( $Y_{sg,h}$ ) to the r.m.s. value of the sub-group associated with the fundamental ( $Y_{sg,1}$ ):

$$THDS_Y = \sqrt{\sum_{h=h_{\min}}^{h_{\max}} \left( \frac{Y_{sg,h}}{Y_{sg,1}} \right)^2} \quad \text{where } h_{\min} \geq 2 \quad (6)$$

NOTE 1 The symbol  $Y$  is replaced, as required, by the symbol  $I$  for currents or by the symbol  $U$  for voltages.

NOTE 2 The value of  $h_{\min}$  is 2 and that of  $h_{\max}$  is 40 if no other values are defined in a standard concerned with limits (for example IEC 61000-3 series).

**3.3.4****partial weighted harmonic distortion****PWHD** **$PWHD_{H,Y}$**  (symbol)

ratio of the r.m.s. value, weighted with the harmonic order  $h$ , of a selected group of higher order harmonics (from the order  $h_{\min}$  to  $h_{\max}$ ) to the r.m.s. value of the fundamental:

$$PWHD_{H,Y} = \sqrt{\sum_{h=h_{\min}}^{h_{\max}} h \left( \frac{Y_{H,h}}{Y_{H,1}} \right)^2} \quad (7)$$

NOTE 1 The symbol  $Y$  is replaced, as required, by the symbol  $I$  for currents or by the symbol  $U$  for voltages.

NOTE 2 The concept of partial weighted harmonic distortion is introduced to allow for the possibility of specifying a single limit for the aggregation of higher order harmonic components. The partial weighted group harmonic distortion  $PWHD_{g,Y}$  can be evaluated by replacing the quantity  $Y_{H,h}$  by the quantity  $Y_{g,h}$ . The partial weighted sub-group harmonic distortion  $PWHD_{sg,Y}$  can be evaluated by replacing the quantity  $Y_{H,h}$  by the quantity  $Y_{sg,h}$ . The type of  $PWHD$  ( $PWHD_{H,Y}$ ,  $PWHD_{g,Y}$  or  $PWHD_{sg,Y}$ ) is defined in each standard which uses the  $PWHD$ , for example in standards concerned with limits (IEC 61000-3 series).

NOTE 3 The values of  $h_{\min}$  and  $h_{\max}$  are defined in each standard which uses the  $PWHD_Y$ , for example in a standard concerned with limits (IEC 61000-3 series).

**3.4 Definitions related to interharmonics****3.4.1****r.m.s. value of a spectral component** **$Y_{C,k}$** 

in the analysis of a waveform, the r.m.s. value of a component whose frequency is a multiple of the inverse of the duration of the time window

NOTE 1 If the duration of the time window is multiple of the fundamental period, only some of the spectral components have frequencies which are integer multiples of the fundamental frequency.

NOTE 2 The frequency interval between two consecutive spectral components is the inverse of the width of the time window, approximately 5 Hz for the purposes of this standard.

NOTE 3 The symbol  $Y$  is replaced, as required, by the symbol  $I$  for currents or by the symbol  $U$  for voltages.

**3.4.2****r.m.s. value of an interharmonic component** **$Y_{C,i}$** 

r.m.s. value of a spectral component,  $Y_{C,k} \neq h \times N$ , with a frequency between two consecutive harmonic frequencies (see Figure 4). For brevity, such a component may be referred to simply as an “interharmonic”.

NOTE 1 The frequency of the interharmonic component is given by the frequency of the spectral line. This frequency is not an integer multiple of the fundamental frequency.

NOTE 2 A difference is made between an “interharmonic component” produced as a physical component by an equipment, for example at 183,333 Hz, and a “spectral component” calculated by the instrument as the result of the waveform analysis e.g. for a 50 Hz system at 185 Hz (the frequency of the FFT bin). The “spectral component” is also the “harmonic component” for  $h \times N$  where  $h$  is an integer.

### 3.4.3

#### r.m.s. value of an interharmonic group

$Y_{ig,h}$

r.m.s. value of all spectral components in the interval between two consecutive harmonic frequencies (see Figure 4).

NOTE 1 For the purpose of this standard, the r.m.s. value of the interharmonic group between the harmonic orders  $h$  and  $h + 1$  is designated as  $Y_{ig,h}$ , for example the group between  $h = 5$  and  $h = 6$  is designated as  $Y_{ig,5}$ .

NOTE 2 The symbol  $Y$  is replaced, as required, by the symbol  $I$  for currents or by the symbol  $U$  for voltages.

### 3.4.4

#### r.m.s. value of an interharmonic centred subgroup

$Y_{isg,h}$

r.m.s. value of all spectral components in the interval between two consecutive harmonic frequencies, excluding spectral components directly adjacent to the harmonic frequencies (see Figure 6)

NOTE 1 For the purpose of this standard, the r.m.s. value of the centred subgroup between the harmonic orders  $h$  and  $h + 1$  is designated as  $Y_{isg,h}$ , for example the centred subgroup between  $h = 5$  and  $h = 6$  is designated as  $Y_{isg,5}$ .

NOTE 2 The symbol  $Y$  is replaced, as required, by the symbol  $I$  for currents or by the symbol  $U$  for voltages.

### 3.4.5

#### interharmonic group frequency

$f_{ig,h}$

mean of the two harmonic frequencies between which the group is situated, i.e.  $f_{ig,h} = (f_{H,h} + f_{H,h+1})/2$ .

### 3.4.6

#### interharmonic centred subgroup frequency

$f_{isg,h}$

mean of the two harmonic frequencies between which the subgroup is situated, i.e.  $f_{isg,h} = (f_{H,h} + f_{H,h+1})/2$ .

## 3.5 Notations

### 3.5.1 Symbols

In this standard, voltage and current values are r.m.s. unless otherwise stated.

|             |                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------|
| $a$         | amplitude coefficient of a cosine component in a Fourier series                                         |
| $b$         | amplitude coefficient of a sine component in a Fourier series                                           |
| $c$         | amplitude coefficient in a Fourier series                                                               |
| $f$         | frequency; function                                                                                     |
| $f_{C,k}$   | spectral component frequency of order $k$                                                               |
| $f_{C,1}$   | the frequency of the spectral component of order 1. The frequency resolution is equal to this frequency |
| $f_{g,h}$   | harmonic-group frequency of order $h$                                                                   |
| $f_{sg,h}$  | harmonic-subgroup frequency of order $h$                                                                |
| $f_{ig,h}$  | interharmonic-group frequency of order $h$                                                              |
| $f_{isg,h}$ | interharmonic centred subgroup frequency of order $h$                                                   |
| $f_{H,h}$   | harmonic component frequency of order $h$                                                               |
| $f_{H,1}$   | fundamental frequency of the power system                                                               |
| $f_s$       | sampling rate                                                                                           |
| $h_{\max}$  | the order of the highest harmonic that is taken into account                                            |
| $h_{\min}$  | the order of the lowest harmonic that is taken into account                                             |
| $j$         | $\sqrt{-1}$                                                                                             |

|             |                                                           |
|-------------|-----------------------------------------------------------|
| $t$         | running time                                              |
| $B$         | bandwidth                                                 |
| $I$         | current (r.m.s. value)                                    |
| $M$         | integer number; number of samples within the window width |
| $N$         | number of power supply periods within the window width    |
| $P$         | power                                                     |
| $T$         | time interval                                             |
| $T_1$       | fundamental period of the power supply system             |
| $T_N$       | window width comprising $N$ fundamental periods           |
| $U$         | voltage (r.m.s. value)                                    |
| $Y$         | Variable replaceable by $I, U$                            |
| $Y_{C,k}$   | r.m.s. value of the spectral component of order $k$       |
| $Y_{g,h}$   | r.m.s. value of harmonic group                            |
| $Y_{H,h}$   | r.m.s. value of the harmonic component of order $h$       |
| $Y_{ig,h}$  | r.m.s. value of interharmonic group                       |
| $Y_{isg,h}$ | r.m.s. value of interharmonic centred subgroup            |
| $Y_{sg,h}$  | r.m.s. value of harmonic subgroup                         |
| $\omega$    | angular frequency                                         |
| $\omega_1$  | angular frequency of the power supply                     |
| $\varphi$   | phase angle                                               |

### 3.5.2 Subscripts

|         |                                                          |
|---------|----------------------------------------------------------|
| $b$     | centre-band frequency                                    |
| $h$     | running-integer number for harmonic orders               |
| $k$     | running-integer number for spectral components           |
| $m$     | measured value                                           |
| max     | maximum value                                            |
| min     | minimum value                                            |
| $o$     | smoothed value                                           |
| $g$     | grouped value                                            |
| $sg$    | sub-grouped value                                        |
| $i$     | interharmonic value                                      |
| $g,h$   | harmonic group associated with harmonic order $h$        |
| $sg,h$  | harmonic subgroup associated with harmonic order $h$     |
| $ig,h$  | interharmonic group above harmonic order $h$             |
| $isg,h$ | interharmonic centred sub-group above harmonic order $h$ |
| $og,h$  | smoothed harmonic group of order $h$                     |
| nom     | nominal value                                            |
| s       | sampled                                                  |
| C       | value related to spectral component                      |
| H       | harmonic                                                 |
| $f$     | frequency                                                |
| 0       | d.c. related                                             |

## 4 General concepts and common requirements for all types of instrumentation

### 4.1 Characteristics of the signal to be measured

Instruments for the following types of measurement are considered:

- a) harmonic emission measurement,
- b) interharmonic emission measurement,
- c) measurements above harmonic frequency range up to 9 kHz.

Strictly speaking the (Fast) Fourier Transform produces accurate results for steady state signals only. Signals whose amplitudes vary with time cannot be described correctly by their harmonic components only. In order to obtain reproducible harmonic emission analysis results when measuring products with fluctuating power, and thus fluctuating fundamental current and possibly fluctuating harmonic current levels, a combination of averaging techniques and sufficiently long measurement cycles can be used. This standard therefore provides a simplified method employing specific averaging methods (see 5.5.1). Furthermore, a test observation period, long enough to obtain successive measurement results that are within acceptable tolerance levels is specified in the harmonic emission standards referring to this standard.

### 4.2 Accuracy classes of instrumentation

Two classes of accuracy (I and II) are considered, to permit the use of simple and low-cost instruments, consistent with the requirements of the application. For emission tests, the upper class I is required if the emissions are near to the limit values (see also note 2 of table 1).

### 4.3 Types of measurement

Requirements for harmonic and interharmonic measurements are given. Measurements in the frequency range up to 9 kHz are also considered.

### 4.4 General structure of the instrument

New designs of instrument are likely to use the discrete Fourier transform (DFT), normally using a fast algorithm called fast Fourier transform (FFT). Therefore this standard considers only this architecture but does not exclude other analysis principles (see clause 6).

The general structure is represented in figure 1. An instrument may or may not comprise all the blocks and outputs given.

#### 4.4.1 Main instrument

The main instrument comprises

- input circuits with anti-aliasing filter,
- A/D-converter including sample-and-hold unit,
- synchronisation and window-shaping unit if necessary,
- DFT-processor providing the Fourier coefficients  $a_k$  and  $b_k$  ("OUT 1").

It is complemented by the special parts devoted to current assessment and/or voltage assessment.

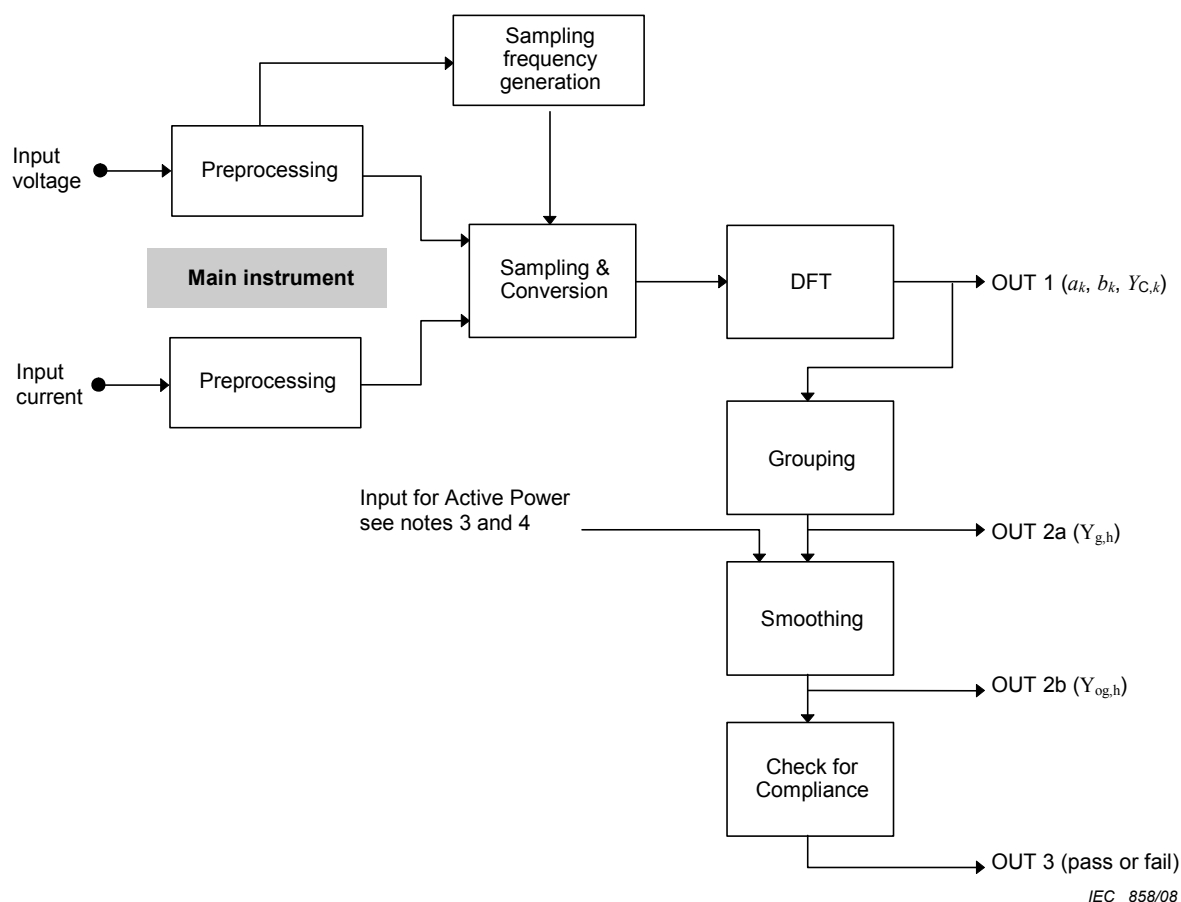
NOTE 1 For further details, see 5.5.

NOTE 2 For the analysis of harmonics and interharmonics, the signal  $f(t)$  which has to be analysed is pre-treated to eliminate frequencies higher than the operating range of the instrument.

The window width shall be 10 (50 Hz systems) or 12 (60 Hz systems) fundamental periods ( $T_N = [10 \text{ or } 12] \times T_1 \approx 200\text{ms}$ ) with rectangular weighting, synchronized to the fundamental frequency of the power system. Hanning weighting is allowed only in the case of loss of synchronisation. The loss of synchronisation shall be indicated on the instrument display and the data so acquired shall be flagged and shall not be used for the purpose of determining compliance, but may be used for other purposes.

The time window shall be synchronised with each group of 10 or 12 cycles according to the power system frequency of 50 Hz or 60 Hz. The time between the leading edge of the first sampling pulse and the leading edge of the  $(M+1)$ th sampling pulse (where  $M$  is the number of samples; see 3.5.1) shall be equal to the duration of the specified number of cycles of the power system, with a maximum permissible error of  $\pm 0,03\%$ . Instruments including a phase-locked loop or other synchronisation means shall meet the requirements for accuracy and synchronisation for measuring at any signal frequency within a range of at least  $\pm 5\%$  of the nominal system frequency. However, for instruments having integrated supply sources, so that the source and measurement systems are inherently synchronised, the requirement for a working input frequency range does not apply, provided the requirements for synchronisation and frequency accuracy are met.

The output OUT 1 (see Figure 1) shall provide the individual coefficients  $a_k$  and  $b_k$  of the DFT as well as  $Y_{C,k}$ , for the current or voltage, i.e. the value of each frequency component calculated.



IEC 858/08

Figure 1 – General structure of the measuring instrument

A further output, not necessarily from the DFT, shall provide the active power  $P$  evaluated over the same time window used for the harmonics. For the harmonic emission measurements according to IEC 61000-3-2, this power shall not include the d.c. component.

NOTE 3 The active power  $P$  is provided as input to the smoothing process, not to the grouping process.

NOTE 4 Measurement of the d.c. components and of the power associated with them may be included as an option but is not required by this standard.

#### 4.4.2 Post-processing parts

As required by emission standards, additional operations on the raw data like smoothing and weighing of the raw results are performed in successive parts of the instrument.

If output values are to be related to a corresponding value (fundamental, declared or nominal values), this normalization shall be performed only after these additional smoothing procedures.

### 5 Harmonic measurements

#### 5.1 Current input circuit

The input circuit shall be suitable for the currents to be analysed. It shall provide a direct measurement of the harmonic currents and, in addition, should have a low-voltage high-impedance voltage input which may be associated with external resistive shunts (or a combination of current transformers with resistive shunts). Appropriate input circuit sensitivities range from 0,1 V to 10 V, with 0,1 V being the preferred value, provided they comply with the requirements given in 5.3.

NOTE For current measurements directly in the circuit, it may be advisable, but is not required, to provide the following nominal r.m.s. input current measurement ranges  $I_{nom}$ : 0,1 A ; 0,2 A ; 0,5 A ; 1 A ; 2 A ; 5 A ; 10 A ; 20 A ; 50 A ; 100 A.

The power absorption of the current input circuit shall not exceed 3 VA for class II instrumentation. For class I instrumentation, the r.m.s. input voltage drop shall not exceed 0,15 V.

Each current input circuit shall be able to be continuously stressed by  $1,2 I_{nom}$  and a stressing by  $10 I_{nom}$  for 1 s shall not lead to any damage.

The instrument shall be able to accept input signals with a crest factor up to 4 for the ranges up to 5 A r.m.s., 3,5 for the 10 A r.m.s. range and 2,5 for higher ranges.

An overload indication is required.

The overall accuracy requirements are stated in table 1.

For other requirements, see clause 8.

NOTE A d.c. component is often associated with the distorted current to be measured; such a d.c. component may produce large errors in input current transformers. The manufacturer should indicate in the instrumentation specifications the maximum allowed d.c. component so that the additional influence error does not exceed the stated accuracy.

## 5.2 Voltage input circuit

The input circuit of the measuring instrument shall be suitable for the maximum voltage and the frequency of the supply voltage to be analysed and shall keep its characteristics and accuracy unchanged up to 1,2 times the maximum voltage. A crest factor of at least 1,5 is sufficient for measurements, except for highly distorted voltages in industrial networks, for which a crest factor of at least 2 may be necessary. An overload indication is required in any case.

Stressing the input for 1 s by an a.c. voltage of four times the input voltage setting or 1 kV r.m.s., whichever is less, shall not lead to any damage in the instrument.

Many nominal supply voltages between 60 V and 690 V exist, depending on local practice. 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:

$U_{\text{nom}}$  : 66 V, 115 V, 230 V, 400 V, 690 V for 50 Hz systems

$U_{\text{nom}}$  : 69 V, 120 V, 240 V, 277 V, 347 V, 480 V, 600 V for 60 Hz systems.

NOTE 1 In association with external voltage transformers, additional ranges may also be useful (100 V,  $100/\sqrt{3}$  V,  $110/\sqrt{3}$  V)

NOTE 2 Inputs with higher sensitivity (0,1 V; 1 V; 10 V) are useful for operation with external sensors. The input circuit should be capable of accepting an input signal with a crest factor of at least 2.

The power absorption of the input circuit shall not exceed 0,5 VA at 230 V. If high-sensitivity inputs (less than 50 V) are provided, their input resistance shall be at least 10 k $\Omega$ /V.

Care should be taken that the high value of the fundamental (supply frequency) voltage as compared to the other voltage components to be measured does not produce overload causing damage or intermodulation signals in the input stages of the instrument. Errors so caused shall be below the stated accuracy. An overload indication shall be provided.

## 5.3 Accuracy requirements

Two classes of accuracy are suggested for instrumentation measuring harmonic components. The maximum allowable errors given in table 1 refer to single-frequency and steady-state signals, in the operating frequency range, applied to the instrument under rated operating conditions to be indicated by the manufacturer (temperature range, humidity range, instrument supply voltage, etc.).

NOTE When testing appliances according to IEC 61000-3-2, the uncertainty terms are related to the permissible limits (5 % of the permissible limits) or to the rated current ( $I_r$ ) of the tested appliance (0,15 %  $I_r$ ), whichever is greater. This should be considered when choosing the proper input current range of the measuring instrument.

**Table 1 – Accuracy requirements for current, voltage and power measurements**

| Class                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Measurement | Conditions                                        | Maximum error                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------|---------------------------------------|
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Voltage     | $U_m \geq 1\% U_{nom}$<br>$U_m < 1\% U_{nom}$     | $\pm 5\% U_m$<br>$\pm 0,05\% U_{nom}$ |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Current     | $I_m \geq 3\% I_{nom}$<br>$I_m < 3\% I_{nom}$     | $\pm 5\% I_m$<br>$\pm 0,15\% I_{nom}$ |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Power       | $P_m \geq 150 \text{ W}$<br>$P_m < 150 \text{ W}$ | $\pm 1\% P_m$<br>$\pm 1,5 \text{ W}$  |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Voltage     | $U_m \geq 3\% U_{nom}$<br>$U_m < 3\% U_{nom}$     | $\pm 5\% U_m$<br>$\pm 0,15\% U_{nom}$ |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Current     | $I_m \geq 10\% I_{nom}$<br>$I_m < 10\% I_{nom}$   | $\pm 5\% I_m$<br>$\pm 0,5\% I_{nom}$  |
| $I_{nom}$ : Nominal current range of the measurement instrument<br>$U_{nom}$ : Nominal voltage range of the measurement instrument<br>$U_m$ , $I_m$ and $P_m$ : Measured values.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |                                                   |                                       |
| <p>NOTE 1 Class I instruments are recommended where precise measurements are necessary, such as for verifying compliance with standards, resolving disputes, etc. Any two instruments that comply with the requirements of Class I, when connected to the same signals, produce matching results within the specified accuracy (or indicate an overload condition).</p> <p>NOTE 2 Class I instruments are recommended for emission measurements, Class II is recommended for general surveys, but can also be used for emission measurements if the values are such that, even allowing for the increased uncertainty, it is clear that the limits are not exceeded. In practice, this means that the measured values of harmonics should be &lt;90 % of the allowed limits.</p> <p>NOTE 3 Additionally, for Class I instruments, the phase shift between individual channels should be smaller than <math>h \times 1^\circ</math>.</p> |             |                                                   |                                       |

Frequencies outside the measuring range of the instrument shall be attenuated so as not to affect the results. To obtain the appropriate attenuation, the instrument may sample the input signal at a frequency much higher than the measuring range. For example, the analysed signal may have components exceeding 25 kHz, but only components up to 2 kHz are taken into account. An anti-aliasing low-pass filter, with a –3 dB frequency above the measuring range shall be provided. The attenuation in the stop-band shall exceed 50 dB.

NOTE For example, a 5th order Butterworth filter achieves 50 dB attenuation at approximately three times the –3 dB frequency.

When it is necessary to assess harmonics with an order greater than 15 and with a rated current greater than 5 A with the minimum uncertainty, it is advisable to use external shunts or current sensors matched to give a range equal to the rated current of the tested equipment.

For instrumentation intended for measuring harmonics only, the accuracy requirements apply to harmonic components only.

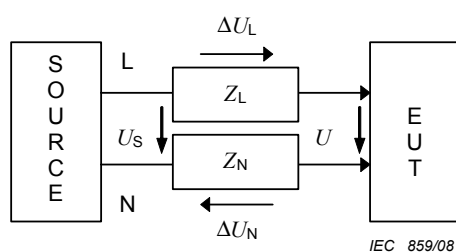
To achieve the accuracy stated in table 1 some simple adjustment of the instrument, according to clear indications to be given by the manufacturer, by means of an internal or external calibrator may be required. The uncertainty of the calibrator (if internal) shall be specified.

The errors due to the most important influence factors (temperature, auxiliary mains supply voltage, etc.) shall be indicated by the manufacturer for the instrument itself and for the internal calibrator if it is provided.

## 5.4 Measurement set-up and supply voltage

### 5.4.1 Measurement set-up for emission assessment

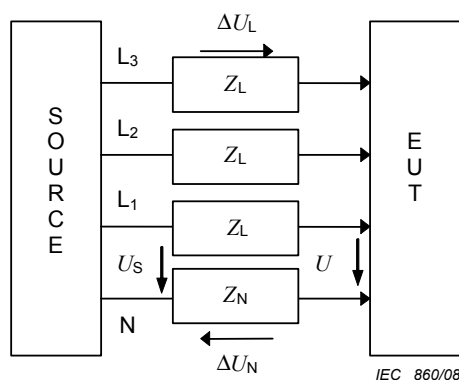
The measurement set-up is given in Figures 2 and 3.



#### Key

|            |                                                                              |
|------------|------------------------------------------------------------------------------|
| $U_S$      | Source voltage line-neutral                                                  |
| $U$        | EUT terminal voltage                                                         |
| $Z_{L,N}$  | Impedance of wiring and current sensing part                                 |
| EUT        | Equipment under test                                                         |
| $\Delta U$ | Voltage drop across $Z_L$ and $Z_N$ ( $\Delta U = \Delta U_L + \Delta U_N$ ) |
| L          | Line connection                                                              |
| N          | Neutral connection                                                           |

Figure 2 – Measurement set-up for single-phase emission measurement



#### Key

|            |                                                                                                                                              |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| $U_S$      | Source voltage line-neutral                                                                                                                  |
| $U$        | EUT terminal voltage                                                                                                                         |
| $Z_{L,N}$  | Impedance of wiring and current sensing part                                                                                                 |
| EUT        | Equipment under test                                                                                                                         |
| $\Delta U$ | Voltage drop across $Z_L$ and $Z_N$ ( $\Delta U = \Delta U_L + \Delta U_N$ );<br>For interphase connection, $\Delta U = 2 \times \Delta U_L$ |
| $L_{1-3}$  | Line connections                                                                                                                             |
| N          | Neutral connection                                                                                                                           |

Figure 3 – Measurement set-up for three-phase emission measurements

### 5.4.2 Supply voltage for emission assessment

#### 5.4.2.1 General

While measurements for assessing harmonics up to the 40th harmonic of the mains frequency are being made, the test voltage  $U$  at the terminals of the EUT shall meet the following requirements:

#### 5.4.2.2 Requirements for equipment with input current less than or equal to 16 A per phase

The following requirements for equipment with input current  $\leq 16$  A per phase shall be met:

- The stability of the test voltage shall be maintained within  $\pm 2$  % of the selected value and the frequency shall be maintained within  $\pm 0,5$  % of the selected value during the test. If the EUT has a specified supply voltage range, the test voltage shall correspond to the nominal voltage of the power system expected to supply the equipment (for example, 230 V line-neutral, corresponding to 400 V line-line). In order to facilitate ease of measurements, for three-wire, three-phase delta connections, an artificial neutral point realized with three resistors matched within 1 % may be used if the neutral conductor is not available from the source. The purpose of the artificial neutral point is to permit voltage and power-per-phase measurements to be made in a line-to-neutral configuration as well as line-to-line. The errors introduced into measurements of EUT currents, during emission tests by the loading effect of the voltmeter part of the instrument and any installed artificial neutral network shall not exceed 0,05 %.

NOTE In many cases the artificial neutral is not required, but if it is, several approaches can be used. It may be provided by the three input impedances of the voltmeters in the measuring instrument. Alternatively, the artificial neutral may effectively consist of the combined effect of an explicit network plus the input impedances of the voltmeters in the measuring instrument. It is also possible that the artificial neutral network, if it is present, and the input impedances of the voltmeters may be so connected as not to introduce any errors in current measurements (because the loading occurs on the source side of the current transducer). In still other cases, errors introduced by the loading effect of the artificial neutral network and the input impedances of the voltmeters in the instrument may be adequately compensated by regulating feedback loops in the source such that errors that otherwise might be introduced do not, in fact, occur. Many other configurations may be satisfactory, provided the required uncertainty is not exceeded.

- b) For a three-phase supply, the three line voltages shall have a phase relationship of  $0^\circ$ ,  $120^\circ \pm 1,5^\circ$ ,  $240^\circ \pm 1,5^\circ$ .
- c) The voltage harmonic distortion of the EUT test voltage  $U$  shall not exceed the following values with the EUT connected and operating under the specified test conditions:
  - 0,9 % for harmonic of order 3;
  - 0,4 % for harmonic of order 5;
  - 0,3 % for harmonic of order 7;
  - 0,2 % for harmonic of order 9;
  - 0,2 % for even harmonics of order from 2 to 10;
  - 0,1 % for harmonics of order from 11 to 40.
- d) The peak value of the test voltage shall be within a range of 1,404 to 1,424 times its r.m.s. value and shall be reached between  $87^\circ$  and  $93^\circ$  after the zero crossing.
- e) The voltage drop  $\Delta U$  across the impedance of the current sensing part and the wiring shall not exceed a peak voltage of 0,5 V.

#### **5.4.2.3 Requirements for equipment with input current above 16 A and less than or equal to 75 A per phase**

The following requirements for equipment with input current  $>16$  A and  $\leq 75$  A per phase shall be met:

- a) The output voltage  $U$  shall be the rated voltage of the equipment. In the case of a voltage range, the output voltage shall be a nominal system voltage according to IEC 60038 (for example: 120 V or 230 V for single-phase or 400 V line-line for three-phase). In order to facilitate ease of measurements, for three-wire, three-phase delta connections, an artificial neutral point realized with three resistors matched within 1 % may be used if the neutral conductor is not available from the source. The purpose of the artificial neutral point is to permit voltage and power-per-phase measurements to be made in a line-to-neutral configuration as well as line-to-line. The errors introduced into measurements of EUT currents, during emission tests by the loading effect of the voltmeter part of the instrument and any installed artificial neutral network shall not exceed 0,05 %.
- b) The output voltage shall be maintained within  $\pm 2,0$  % and the frequency within  $\pm 0,5$  % of the nominal value.
- c) In the case of a three-phase supply, the voltage unbalance shall be less than 50 % of the voltage unbalance compatibility level given in IEC 61000-2-2.
- d) The harmonic ratios of the output voltage  $U$  in no-load condition shall not exceed:
  - 1,5 % for harmonic of order 5;
  - 1,25 % for harmonics of order 3 and 7;
  - 0,7 % for harmonic of order 11;
  - 0,6 % for harmonics of order 9 and 13;
  - 0,4 % for even harmonics of order 2 to 10;
  - 0,3 % for harmonics of order 12 and 14 to 40.

- e) For the application of Tables 2 and 3 in IEC 61000-3-12, the impedance of the supply source is such that the short-circuit ratio  $R_{sce}$  (as defined in IEC 61000-3-12) is equal to or higher than the minimum  $R_{sce}$  value ( $R_{sce\ min}$ ) allowing the compliance of the equipment, with possible insertion of reactors. For the application of Table 4 in IEC 61000-3-12, the impedance of the supply source is such that the  $R_{sce}$  is equal to or higher than 1,6 times the minimum  $R_{sce}$  value allowing the compliance of the equipment, with possible insertion of reactors.

NOTE 1 The factor 1,6 is intended to take into account the fact that if an equipment is connected to a supply that gives a higher  $R_{sce}$  value than  $R_{sce\ min}$ , the harmonic emission currents increase. An allowance for this is already included in Tables 2 and 3 in IEC 61000-3-12, so that no further allowance in terms of the value of  $R_{sce}$  to be used for testing is considered necessary.

- f) The impedance of the current-sensing part and the wiring is included in the impedance of the supply source.

NOTE 2 The values of impedance and distortion given above have been chosen as a compromise, considering that high quality supplies of very high current capacity are extremely rare. The repeatability of results, using different supplies, can be very poor with the above-mentioned values of distortion and impedance. The repeatability using the same supply is not so poor. If at all possible, a supply with lower distortion and impedance should be used.

### 5.4.3 Equipment power

Equipment power, if required, shall be measured using the EUT terminal voltage  $U$  in Figure 2 or Figure 3 and the current into the EUT. For sources that include the current sensing part, equipment power shall be measured using the voltage at the source output terminals and the current into the EUT. In this case, the voltage shall be measured on the EUT side of the current sensing part on the presumption that the source is regulated at its output terminals.

## 5.5 Assessment of harmonic emissions

The following relates to the post-processing parts of figure 1.

### 5.5.1 Grouping and smoothing

For assessment of harmonics, the output OUT 1 (see figure 1) of the DFT is first grouped to be the sum of squared intermediate components between two adjacent harmonics according to equation 8, visualized in figure 4. Only intermediate components above the second order harmonic shall be used. The resulting harmonic group of order  $h$  (corresponding to the centre component in the hatched area) has the magnitude  $Y_{g,h}$  (for 50 Hz this magnitude equals the square root of the sum of the integer harmonic bin value squared plus the squared values of the adjacent bins from  $n - 4$  through  $n + 4$  plus half of the squared values of the  $n - 5$  bin and  $n + 5$  bin).

$$Y_{g,h}^2 = \frac{1}{2} \cdot Y_{C,(N \times h) - N/2}^2 + \sum_{k=(-N/2)+1}^{(N/2)-1} Y_{C,(N \times h)+k}^2 + \frac{1}{2} \cdot Y_{C,(N \times h) + N/2}^2 \quad (8)$$

NOTE In this equation, only intermediate components above the second order harmonic are taken into account.

In this equation,  $Y_{C,(N \times h)+k}$  is the r.m.s. value of the spectral component corresponding to an output bin (spectral component) of the DFT,  $(N \times h) + k$  is the order of the spectral components, and  $Y_{g,h}$  is the resulting r.m.s. value of the harmonic group.

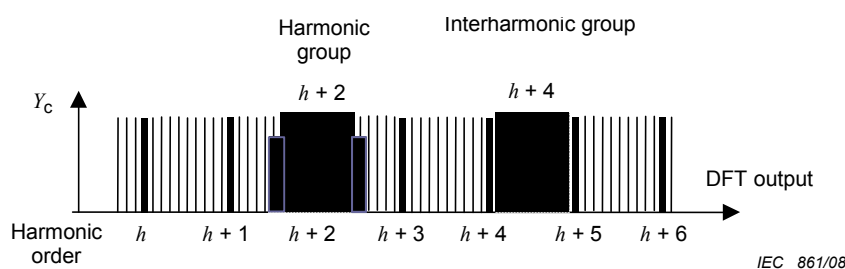


Figure 4 – Illustration of harmonic and interharmonic groups  
(here shown for a 50-Hz supply)

NOTE The grouping of interharmonics is illustrated in Figure 4 only to clarify the definitions (see Annex A for interharmonic current assessment).

A smoothing of the signal shall be performed over the r.m.s. value  $Y_{g,h}$  of each harmonic order, according to equation 8 (OUT 2a of Figure 1), using a digital equivalent of a first order low-pass filter with a time constant of 1,5 s, as shown in Figure 5.

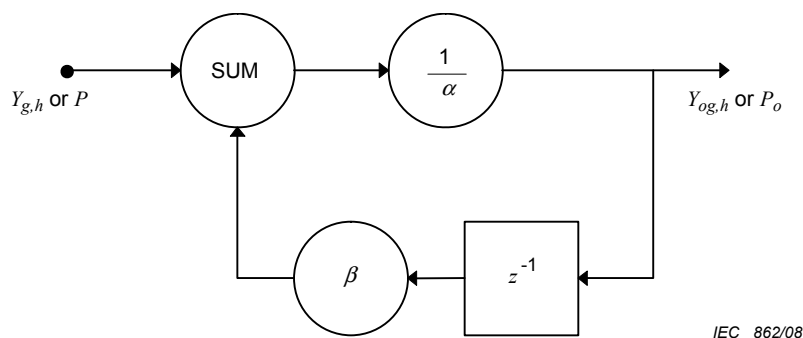


**Figure 5 – Realization of a digital low-pass filter:  $z^{-1}$  designates a window width delay,  $\alpha$  and  $\beta$  are the filter coefficients (see Table 2 for values)**

**Table 2 – Smoothing filter coefficients according to the window width**

| Frequency | Cycles N in Window | Sampling Rate<br>(of the digital low-pass filter)<br>ms | $\alpha$ | $\beta$ |
|-----------|--------------------|---------------------------------------------------------|----------|---------|
| 50        | 10                 | $\approx 1/200$                                         | 8,012    | 7,012   |
| 60        | 12                 | $\approx 1/200$                                         | 8,012    | 7,012   |
| 50        | 16                 | $\approx 1/320$                                         | 5,206    | 4,206   |
| 60        | 16                 | $\approx 1/267$                                         | 6,14     | 5,14    |

For the fundamental component  $Y_{H,1}$  (if required, as, for example, for Class C in IEC 61000-3-2 and possibly for distortion factors), the same smoothing of the r.m.s value  $Y_{H,1}$  from OUT 1 shall be performed.

If emission limits include the distortion factors  $THD_Y$  or  $PWHD_{H,Y}$  derived from the harmonic components  $Y_{H,h}$  according to 3.3, they shall be calculated using the values of OUT 1.

If emission limits include the distortion factors  $THDG_Y$ ,  $THDS_Y$ ,  $PWHD_{g,Y}$  or  $PWHD_{sg,Y}$  derived from the grouped values  $Y_{g,h}$  or  $Y_{sg,h}$  according to 3.3, they shall be calculated using the values of OUT 2a.

If a smoothing is required for the above distortion factors in the relevant standards, a digital equivalent of a first-order low-pass filter with a time constant of 1,5 s, as shown in Figure 5 with the coefficients in Table 2, shall be used.

For the active power  $P$  and the power factor (if required as, for example, for Classes C and D in IEC 61000-3-2), a similar smoothing of the modulus of the active power value and the power factor value shall be performed.

NOTE An external power meter may be used provided that the power  $P$  is measured with a time resolution of  $\approx 200$  ms. Therefore, an input for an external power meter may be foreseen at the smoothing block, see Figure 1.

To co-ordinate with surveys of harmonic voltages (see IEC 61000-4-30), it is highly recommended to provide a further type of smoothing, where the output is derived from the components according to equation 8 as an r.m.s. value over 15 contiguous time windows, updated either every time window (about each 200 ms) or every 15 time windows (about each 3 s).

### 5.5.2 Compliance with emission limits

Assessment of compliance with emission limits shall be performed by statistical handling of the data according to the conditions given in the relevant standards, such as IEC 61000-3-2, IEC 61000-3-6, IEC 61000-3-12 and IEC 61000-4-30.

## 5.6 Assessment of voltage harmonic subgroups

The Fourier transform analysis assumes that the signal is stationary. However, the voltage magnitude of the power system may fluctuate, spreading out the energy of harmonic components to adjacent spectral-component frequencies. To improve the assessment accuracy of the voltage, the output components  $U_{C,k}$  for each 5 Hz of the DFT shall be grouped according to Figure 6 and equation 9:

$$Y_{sg,h}^2 = \sum_{k=-1}^1 Y_{C,(N \times h) + k}^2 \quad (9)$$

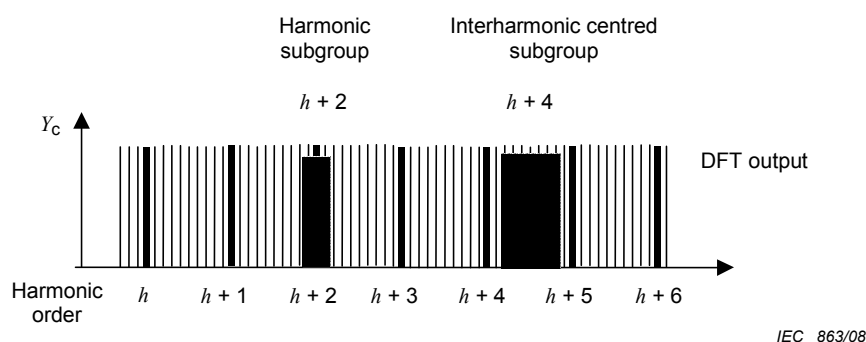


**Figure 6 – Illustration of a harmonic subgroup and an interharmonic centred subgroup (here shown for a 50 Hz supply)**

NOTE Further smoothing procedures to assess voltage subgroups are specified in IEC 61000-4-30.

## 6 Other analysis principles

The fact that this standard specifies a DFT instrument as the reference instrument does not preclude the application of other analysis principles, such as (digital) filter banks or even other analysis principles such as wavelet analysis.

Also, especially for low-cost instruments, a shorter time window, possibly only one period long, can be considered. However, such instrumentation should not be used for assessing the compliance of non-stationary signals with emission limits, as such signals cannot be assessed in this way.

Specifications of instruments based on an alternative analysis principle shall state the range of uncertainty caused by all influence factors including the non-stationary characteristic of the signal, the aliasing phenomenon and the failure of synchronisation. The uncertainty shall be such that the requirements of clause 5 are met.

## 7 Transitional period

The use of the grouping method, particularly with fluctuating loads, is recommended, but for a transitional period the use of existing measuring instruments based upon the requirements given in IEC 61000-4-7 (1991)<sup>1</sup> continues to be permitted. However, measurements performed with such instruments shall be marked in the test report with "Measuring instrumentation according to IEC 61000-4-7, 1991".

NOTE A transitional period is necessary, because changes in IEC 61000-3-2 and IEC 61000-3-12 are necessary for a number of equipments (for example those using symmetrical multi-cycle controls) before applying the grouping approach as explained in 5.5.1.

For measurements performed with instrumentation using 16-cycle windows according to IEC 61000-4-7 1991, the procedure of the smoothing (OUT 2b of figure 1) shall be modified according to the entries in table 2. The filter shall be realised as shown in figure 5.

## 8 General

The manufacturer shall specify the rated operating conditions and possibly the magnitude of error introduced by changes in

- temperature;
- humidity;
- instrument supply voltage and related series interferences;
- common-mode interference voltage between the earth connection of the instrument its input circuits and the auxiliary supply voltage;
- static electricity discharges;
- radiated electromagnetic fields.

NOTE In applying IEC 61010-1 for safety and insulating requirements, it should be taken into account that the input circuits (voltage as well as current) may be directly connected to the mains supply voltages.

<sup>1</sup> IEC 61000-4-7:1991, 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