

IEC 61000-3-2 Harmonics Standards Overview

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Introduction

There have been recent changes to the European Union's Directive to assess compliance of a product's AC mains current harmonics. The purpose of this document is to provide an executive overview of pertinent details and make them easier to understand. For more detailed information please refer to the relevant standards available from the organization concerned.

Harmonics standard IEC 61000-3-2 Ed. 3 2005

This standard assesses and sets the limit for equipment that draws input current $\leq 16A$ per phase. Equipment that draws current $>16A$ and $\leq 75A$ per phase is covered by IEC/TS 61000-3-12. Harmonics measurement and evaluation methods for both standards are governed by IEC 61000-4-7.

Classification of equipment

Equipment can be grouped into one of 4 classes based on the following criteria as evaluated by the IEC committee members:

- Number of pieces of equipment in use (how many (volume) are being used by consumers)
- Duration of use (number of hours in operation)
- Simultaneity of use (are the same type of equipment used on the same time frame)
- Power consumption
- Harmonics spectrum, including phase (how clean or distorted is the current drawn by the equipment)

After all the above criteria are taken into consideration equipment are classified as follows:

Class A	<ul style="list-style-type: none">▪ Balanced three-phase equipment▪ Household appliances, excluding equipment identified by Class D▪ Tools excluding portable tools▪ Dimmers for incandescent lamps▪ Audio equipment▪ Everything else that is not classified as B, C or D
Class B	<ul style="list-style-type: none">▪ Portable tools▪ Arc welding equipment which is not professional equipment
Class C	<ul style="list-style-type: none">▪ Lighting equipment
Class D	<ul style="list-style-type: none">▪ Personal computers and personal computer monitors▪ Television receivers

Note: Equipment must have power level 75W up to and not exceeding 600W

Table 1: Equipment classification

Measurement methods and evaluation

Measurement methods have also gone through a process of evolution. Measuring equipment that has constant power consumption is relatively easier as the harmonics current spectrum remains relatively unchanged in amplitude and phase throughout the test duration. However, if the power level varies over the test duration, the measurement becomes more complicated and complex. Examples of such products are washing machines, photocopiers, printers, air conditioners and variable speed vacuum cleaners. The two measurement methods used to be separate tests but were combined when amendment 14 to IEC 61000-3-2 1995 was introduced in the year 2000.

As mentioned earlier, the whole construction of the analyzer used for testing is governed by IEC 61000-4-7. This standard goes into great detail on how one should measure harmonics emissions for compliance testing. There are two versions of this standard published with amendments that employ two different data acquisition techniques. The older version published in 1991 requires data acquisition in blocks of 320ms data and the later version published in 2001 uses 200ms, both with no gap or overlap between the acquired data blocks. The other variation between the two versions is the introduction of grouped inter-harmonics (harmonics that are not the integer multiple of the fundamental frequency) which are then added to the nearest integer harmonic. All measurements now in use must employ the 1.5s first order filter before the averaging calculation is processed, for each block of data, regardless of product power consumption behavior.

Another important clarification in the Nov 2005 version is that the current harmonics measurement must be done on the line conductor and not the neutral conductor. However, for single phase applications this can be done on the neutral conductor but not in three-phase applications where the values can differ significantly if the EUT is not balanced.

Harmonics [n]	Class A [A]	Class B [A]	Class C [% of fund]	Class D [mA/W]
Odd harmonics				
3	2.30	3.45	30 x λ	3.4
5	1.14	1.71	10	1.9
7	0.77	1.155	7	1.0
9	0.40	0.60	5	0.5
11	0.33	0.495	3	0.35
13	0.21	0.315	3	3.85/13
15 ≤ n ≤ 39	0.15 x 15/n	0.225 X 15/n	3	3.85/n
Even harmonics				
2	1.08	1.62	2	-
4	0.43	0.645	-	-
6	0.30	0.45	-	-
8 ≤ n ≤ 40	0.23 x 8/n	0.345 x 8/n	-	-

Table 2: Harmonics limit

Relaxation against applicable limits

There is an existing relaxation as per A14 in 2000 for higher order harmonics that only applies to a range of high odd harmonics current from the 21st harmonic (1050Hz) to the 39th (1950Hz). This allows the high order harmonic currents to exceed the limits per table 2 (100% of limit) but not exceeding 150% (individual limit x 1.5) as long the Partial Odd Harmonic Current (POHC) average does not exceed the POHC limit.

Example 1:

In a Class A test, harmonics orders 37 and 39 exceeded their respective 100% limit and is <150% of the limit. POHC can then be applied by taking the measured values of H21 to H39 and applying them in the formula below. Do the same calculation for the applicable limits of H21 to H39 per Class A limit and compare the values.

Even though the test report should indicate H37 and H39 as failed (>100% of limit) the overall result for the EUT would be a Pass should measured values be less than the limit calculated.

$$\text{partial odd harmonic current} = \sqrt{\sum_{n=21,23}^{39} I_n^2}$$

Quote from IEC 61000-3-2 ed.2.1 2001

For the 21st and higher odd order harmonics, the average values obtained for each individual odd harmonic over the full observation period, calculated from the 1.5s smoothed r.m.s. values according to 6.2.2 may exceed the applicable limits by 50% provided that the following conditions are met:

- the measured partial odd harmonic current does not exceed the partial odd harmonic current which can be calculate from the applicable limits;
- all 1.5s smoothed r.m.s. individual harmonic current values shall be less than or equal to 150% of the applicable limits.

In this latest version of the harmonics standard, there is a further relaxation for Class A equipment that a manufacturer could employ (please refer to the above excerpt from the standard.). This relaxation would help a Class A product that has short bursts (<10% of test time) that would go beyond the transitory or 150% limit but are less then 200% of the applicable limit. This is allowed as long as the average of the harmonic current is <90% of its limit.

Example 2:

If a 5th order harmonic (250Hz) for a Class A product exceeds 1.71A (1.14A limit x 1.5) but is still below 2.28A (1.14A limit x 2) and this happens for less then 1min of a 10min test duration then the following applies:

The 5th harmonic is considered to have failed the test (it exceeded the 100% limit) but the overall result for that Class A EUT is a pass when the new relaxation is applied.

However, if the same EUT also has high order odd harmonic currents H21-39, per example 1, which exceeded the 100% limit, then one cannot apply both relaxations at the same time as they are mutually exclusive. You can only apply one relaxation for a given test.

Quote from IEC 61000-3-2 Nov 2005

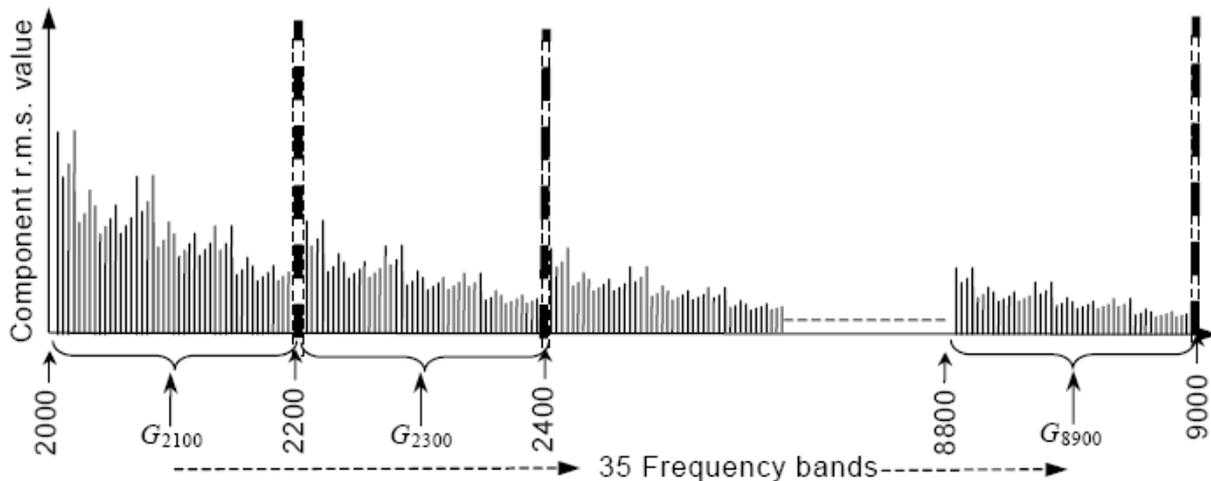
6.2.3.3 Application of limits

The average values for the individual harmonic currents, taken over the entire test observation period shall be less than or equal to the applicable limits.

For each harmonic order, all 1.5s smoothed r.m.s. harmonic current values, as defined in 6.2.2 shall be either:

- a) less than or equal to 150% of the applicable limits, or
- b) less than or equal to 200% of the applicable limits under the following conditions, which apply all together:
 - 1) the EUT belongs to Class A for harmonics;
 - 2) the excursion beyond 150% of the applicable limits lasts less than 10% of the test observation period or in total 10min (within the test observation period), whichever is smaller, and
 - 3) the average value of the harmonic current, taken over the entire test observation period, is less than 90% of the applicable limits.

The other little known requirement is that the 1% power accuracy as per IEC 61000-4-7 2000, section 5.3 table 1 is now a requirement for all power analyzers testing to IEC 61000-3-2. Measurement of inter-harmonics up to 2kHz (harmonics that have no relation to the 50Hz fundamental frequency) should also be considered as part of the testing requirement. In the not too distant future, measurement of harmonics and inter-harmonics from 2kHz to 9kHz with the aid of a device called AMN (Artificial Mains Network) would be implemented in bands or group of 200Hz as shown below.



Summary

The impact of all the changes discussed above indicate that both hardware and software modifications for existing test systems will be required. Therefore it is advantageous to consider measurement systems with an easy upgrade path that will accommodate current standards changes as well as future changes. While dedicated harmonics analyzers require both firmware and software modifications, PC-based analyzers required only software updates, making them a better choice.

	IEC 61000-3-2:1995 Edition 1.0	IEC 61000-3-2:2001 Edition 2.1	IEC 61000-3-2:2005 Edition 3.0
Class D definition	Special waveform envelope (75W to 600W)	TV, PC and PC monitor (75 to 600W)	TV, PC and PC monitor (75 to 600W)
Measurement methods	Steady and transitory	Transitory only	Transitory only
Measurement window	16 cycles (320/267ms @ 50/60Hz)	200ms (10/12 cycles @ 50/60Hz) (16 cycles permitted through 2004) See IEC 61000-4-7 Ed. 2	200ms (10/12 cycles @ 50/60Hz)
Data manipulation	Transitory only	All data must be smoothed using the 1.5s first order filter	All data must be smoothed using the 1.5s first order filter
Pass/Fail for individual harmonics	Every window result <150% of limit 10% of test time >100% permitted	Every window result <150% of limit 10% of test time >100% permitted	Every window result <150% of limit 10% of test time >100% permitted
Class A relaxation*	No special provision	No special provision	<200% of limit only IF >150% for 10% of test time AND Average <90% of limit
Odd harmonics 21-39*	No special provision	Provision for POHC calculation permitting the average of some individual harmonics to >100% (<150%)	Provision for POHC calculation permitting the average of some individual harmonics to >100% (<150%)
Class C & D limits	Proportional to measured power (Class D) Or Current & PF (Class C)	Allows the manufacturer to specify test power or current level, provided it is within $\pm 10\%$ of measured value	Allows the manufacturer to specify test power or current level, provided it is within $\pm 10\%$ of measured value
Test/observation period	Not specifically defined but to find the max. harmonics emission	Specified to be significantly long enough to acquire $\pm 5\%$ repeatability. If too long, select the 2.5min with max. harmonics	Specified to be significantly long enough to acquire $\pm 5\%$ repeatability. If too long, select the 2.5min with max. harmonics
Test conditions	Specified for some products	Detailed test procedure for certain product categories	Detailed test procedure for certain product categories. Amended procedure for testing TV and vacuum cleaners from 2001 version

Table 3: Important differences from various versions of IEC 61000-3-2

* Note: Use either one of the exemption and they cannot be applied together