Class A Measurements of Interharmonics

This work explores the concept of interharmonics and subgrouping; a method introduced by the IEC 61000-4-7 [1] and IEC 61000-4-30 [2] standards to calculate both harmonics and interharmonics. Parameters that quantify the severity of distortion caused by interharmonics are defined and highlighted through examples.

An electrical signal can contain many frequencies. Some are integer multiples of the fundamental (referred to as harmonics) and some are non-integer multiples (referred to as interharmonics). The IEC 61000-4-30 standard defines an interharmonic frequency as "any frequency which is not an integer multiple of the fundamental frequency" [2], and includes frequencies lower than the fundamental, known as subharmonic frequencies.

SUBGROUPS

The IEC 61000-4-7 [1] defines how instruments calculate the Root Mean Square (RMS) for both interharmonics and harmonics of a signal in a power system using the Discrete Fourier Transform (DFT); and requires a window size of 10 cycles for 50Hz and 12 cycles for 60Hz systems. The DFT produces a spectrum of frequency bands (bins) of 5Hz spacing as shown in Figure 1.

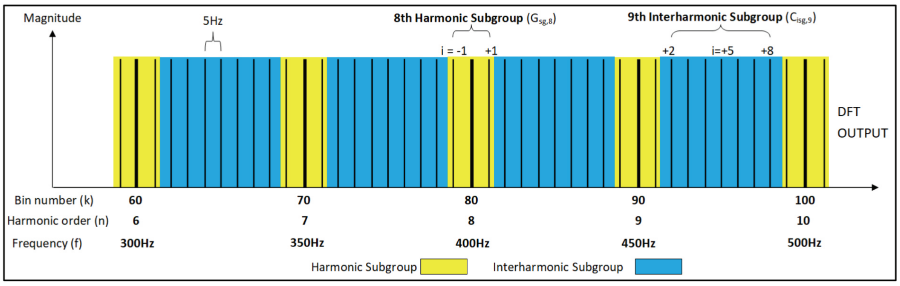

Figure 1 *DFT spectrum for a 50Hz system*

As shown in Figure 1, the harmonic bands are spaced 50Hz apart and highlighted in yellow; the interharmonic bands are highlighted in blue. Harmonic and interharmonic subgroups are made from frequency bands in Figure 1 and are calculated using Equations 1 and 2 as defined in IEC 61000-4-7 [1] and referred to by the IEC 61000-4-30 [2].

$$G_{sg,n}{}^2 = \sum_{i=-1}^{1} C_{k+i}{}^2 \ldots (1)$$

$$C_{isg,n}{}^2 = \sum_{i=2}^{i=m} C_{k+i}{}^2 \ldots (2)$$

Where k is the bin number, $G_{sg,n}$ and $C_{isg,n}$ are the RMS values for the nth harmonic and interharmonic subgroups respectively. The variable m is equal to 8 and 10 for a 50Hz and 60Hz system respectively.

SUBGROUPS - WORKED EXAMPLE

For the spectrum provided in Table 1;

Bin	79	80	81	82	83	84	85	86	87	88	89	90
Frequency (Hz)	395	400	405	410	415	420	425	430	435	440	445	450
Value	0.6	1	0.8	0.5	0.3	0.4	0.5	0.7	0.8	0.9	0.7	0.6

Table 1

Bin	9	10	11	29	30	31	32	33	34	35	36	37	38	39	40
Frequency (Hz)	45	50	55	145	150	155	160	165	170	175	180	185	190	195	200
Value	0	1	0	0	0	0.5	0	0.5	0	0.5	0	0	0	0	0

Table 2 *Note bins 12 to 28 were omitted due to zero magnitude*

The 8th harmonic subgroup is calculated using the values highlighted in yellow as;

$$G_{sg,8} = \sqrt{0.6^2 + 1^2 + 0.8^2} = 1.41$$

While the 8th interharmonic subgroup is calculated using the values highlighted in blue as;

$$C_{isg,8} = \sqrt{0.5^2 + 0.3^2 + 0.4^2 + 0.5^2 + 0.7^2 + 0.8^2 + 0.9^2} = 1.64$$

Subgrouping is used for harmonic magnitude calculation instead of simply using the 5Hz bin RMS at the harmonic in order to take into account spectral leakage caused by the sample window, bin size and/or when the sample window doesn't exactly capture the 10/12 cycles due to slight changes in the fundamental frequency [3].

QUANTIFYING INTERHARMONIC DISTORTION

The interharmonic distortion for the nth interharmonic subgroup is calculated using equation 3.

$$C_{isg,n}(\%) = \frac{C_{isg,n}}{G_{sg,1}} \times 100 \ldots (3)$$

The Total Interharmonic Distortion (TIHD) is defined in equation 4.

$$TIHD(\%) = \frac{\sqrt{C_{isg,0}^2 + C_{isg,1}^2 + C_{isg,2}^2 \ldots + C_{isg,n}^2}}{G_{sg,1}} \times 100 \ldots (4)$$

TIHD - WORKED EXAMPLE

The spectrum in Table 2 was measured using the Miro PQ45 Power Quality Analyser and Logger.

Scenario 1: All frequencies in Table 2 considered.
The fundamental subgroup is calculated using the values highlighted in green as;

$$G_{sg,1} = \sqrt{0^2 + 1^2 + 0^2} = 1$$

The 3rd harmonic subgroup is calculated using the values highlighted in yellow as;

$$G_{sg,3} = \sqrt{0^2 + 0^2 + 0.5^2} = 0.5$$

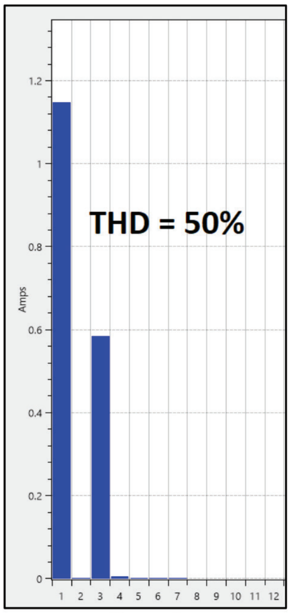

Figure 2

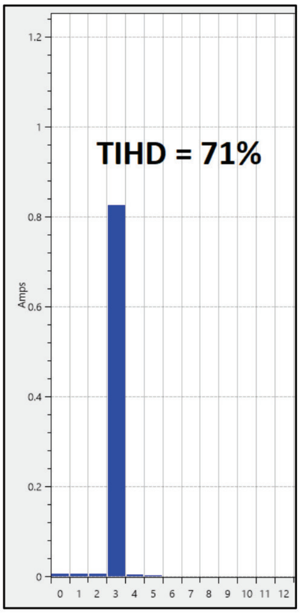

Figure 3

While the 3rd interharmonic subgroup is calculated using the values highlighted in blue as;

$$C_{isg,3} = \sqrt{0^2 + 0.5^2 + 0^2 + 0.5^2 + 0^2 + 0^2 + 0^2} = 0.71$$

$$C_{isg,3}(\%) = 71\%$$

From inspection, TIHD(%) is equal to $C_{isg,3}(\%)$ and THD is equal to 50%. Results are shown in Figure 2 and Figure 3.

Scenario 2: All frequencies in Table 2 considered with bin 31 set to zero.
$G_{sg,3}$ and THD are now equal to zero. All other parameters listed above remain the same, therefore highlighting that the TIHD is unaffected.

References
[1] International Electrotechnical Comission, IEC 61000-4-7-2002 Edition 2: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto, 2002.

[2] International Electrotechnical Comission , IEC61000-4-30-2015: Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods, 2015.

[3] J. V. d. Vegte, Fundamentals of Digital signal Processing, Pearson Education Inc, 2002. T&D

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