PowerMonic Measurement of Harmonics and Interharmonics

Introduction

PowerMonic PM40 measurements comply with IEC Standard 61000-4-7 "*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*".

The PM40 uses a Discrete Fourier Transform (DFT) to calculate harmonics and interharmonic components of the voltage and current waveforms. The DFT input is 10 cycles of the input waveform, and the DFT output bins are spaced at 5 Hz intervals. The first bin (Bin 0) is centered at 0 Hz (DC), the 10th bin is centered at 50 Hz and the Nth bin is centered at 5N Hz. Only the first 482 bins are used, so the last bin (number 481) is centered at 2405 Hz.
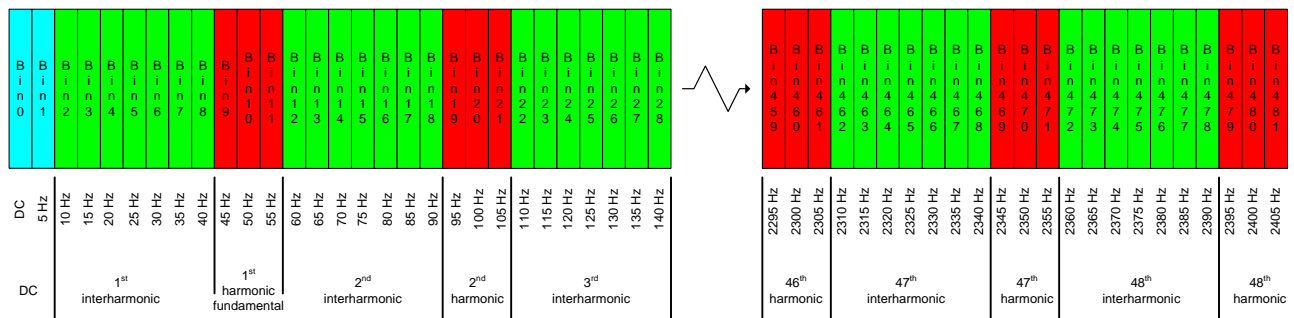

Figure 1 - Graphical representation of harmonics and interharmonics

Harmonic Amplitudes and Phases

The harmonic amplitudes are calculated as

$$H_n = \sqrt{\sum_{i=-1}^{1} C_{10n+i}^2}$$

where C_{10n+i} is the Root Mean Square output of the $(10n+i)th$ bin, centered at frequency $50n - 5i\ Hz$.

The first harmonic or fundamental is therefore combined from the values of the 9th, 10th & 11th bins, with center frequencies of 45, 50 & 55 Hz respectively.

The harmonic phase angle of the nth harmonic is the phase angle of the $10nth$ bin, relative to the phase angle of fundamental (or first harmonic) of the phase A voltage (bin 10).

This phase angle can be used in harmonic power calculations.

Interharmonic Amplitudes

The interharmonic amplitudes are calculated as

$$IH_N = \sqrt{\sum_{i=-8}^{-2} C_{10N+i}^2}$$

where C_{10N+i} is the RMS output of the (10N+i) th bin, centered at frequency $50N - 5i\ Hz$.

The first interhamonic therefore includes bins 2 through 8, with center frequencies of 10 Hz through 40Hz.

The second interharmonic uses bins 12 through 18, with center frequencies of 60 Hz through 90 Hz.

PowerView can display interharmonics as absolute values (Volts or Amps) or as relative values, where the fundamental is assumed to have a magnitude of 100%.

Total Harmonic Distortion

IEC Standard 61000-4-7 defines Total Harmonic Distortion (THD) as the ratio of the Root Mean Square (RMS) sum of all the harmonic components to the RMS value of the first harmonic or fundamental.

Total Harmonic Distortion - Fundamental

In the PM40, this value is known as THD_F and is calculated as

$$THD\_F = \sqrt{\sum_{n=2}^{48} \left(\frac{H_n}{H_1}\right)^2}$$

THD_F is normally expressed as a percentage.

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Total Harmonic Distortion - RMS

When there is severe distortion on the waveform, the total harmonic distortion relative to the RMS value of the waveform is often a more useful measure.

In the PM40, this measurement is known as THD_R, and is calculated as:

$$THD\_R = \sqrt{\sum_{n=2}^{48}\left(\frac{H_n}{V_{RMS}}\right)^2}$$

THD_R is normally expressed as a percentage.

Converting between THD_F and THD_R

To calculate THD_F from THD_R use the following formula:

$$THD\_F = \frac{THD\_R}{\sqrt{1-(THD\_R)^2}}$$

To calculate THD_R from THD_F use the following formula:

$$THD\_R = \frac{THD\_F}{\sqrt{1+(THD\_F)^2}}$$