

Benchmark

SOURCES AND EFFECTS OF HARMONICS

HARMONICS :

Defined as deviations from the fundamental frequency sine wave, expressed as additional sine waves of frequencies that are a multiple of the generated frequency. They are expressed as third, fifth, seventh etc harmonics, denoting their frequency as a multiple of the primary wave frequency.

HARMONICS CONTENT :

A measure of the presence of harmonics in the waveform expressed as a percentage of the fundamental frequency. The total harmonic content is expressed as the square root of the sum of each of the harmonics amplitudes, expressed as percentage of the fundamental.

HARMONIC DISTORTION:

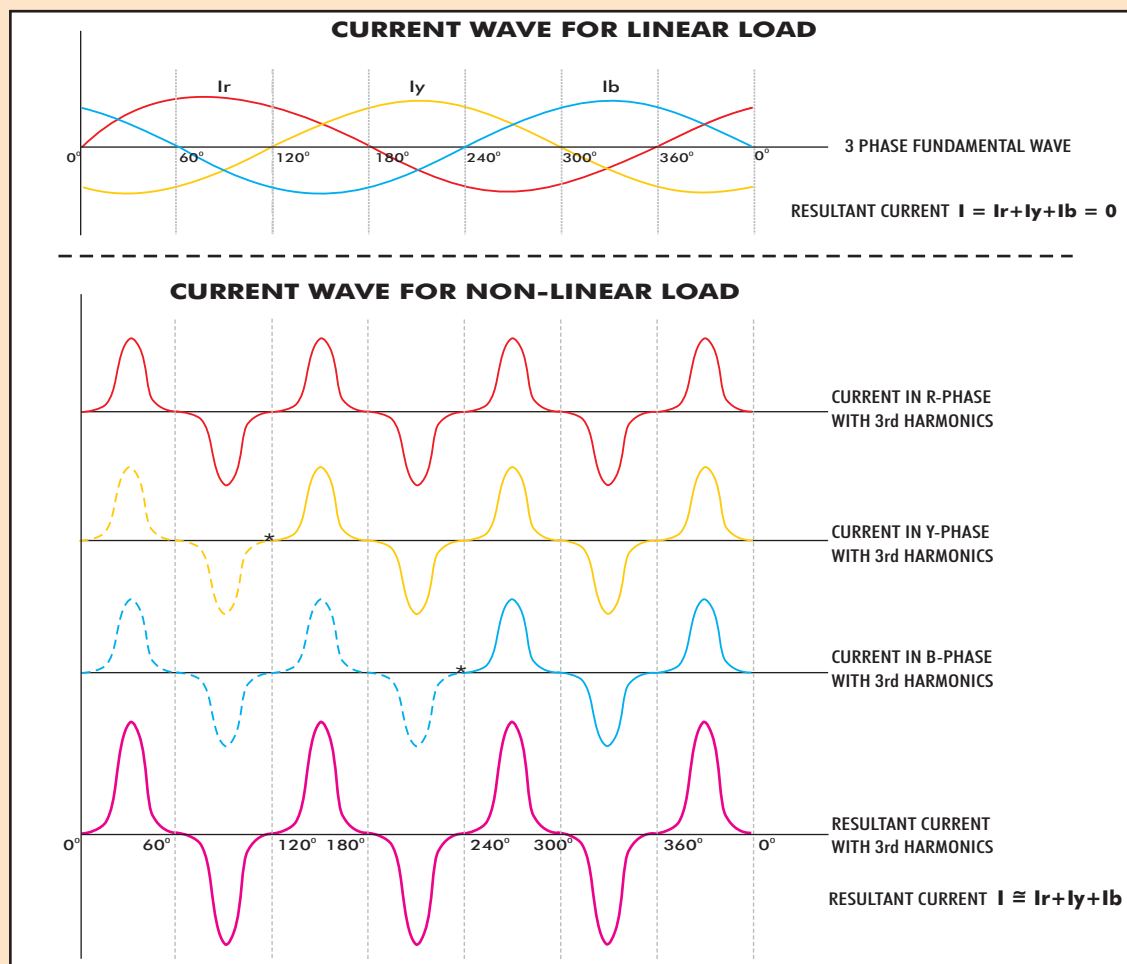
Non linear distortion of a waveform characterized by the appearance in the output of harmonics other than the fundamental component when the input wave is sinusoidal.

LINEAR LOAD :

AC electrical loads where the voltage and current waveforms are sinusoidal. The current at any time is proportional to voltage. Linear Loads are: POWER FACTOR IMPROVEMENT CAPACITORS, INDESCENT LAMPS, HEATERS ETC.

NON-LINEAR LOAD :

Applies to those ac loads where the current is not propotional to the voltage. Foremost among loads meeting their definition are gas discharge lighting having saturated ballast coils and thyritor (SCR) controlled loads. The nature of non-linear loads is to generate harmonics in the current waveform. This distortion of the current waveform leads to distortion of the voltage waveform. Under these conditions, the voltage waveform is no longer proportional to the current. Non Linear Loads are : COMPUTER, LASER PRINTERS, SMPS, REACTIFIER, PLC, ELECTRONIC BALLAST, REFRIGERATOR, TV ETC.



DEFFERENCE BETWEEN LINEAR LOADS AND NON-LINEAR LOADS

S.NO.	LINEAR LOADS	S.NO.	NON-LINER LOADS
1.	Ohms law is applicable	1.	Ohms law is not applicable
2.	Crest Factor= $\frac{1_{Peak}}{1_{RMS}} = \sqrt{2} = 1.41$	2.	Crest Factor could be 3 to 4
3.	Power factor= $\frac{Watts}{V \times I} = \cos \phi$	3.	Power factor= $\frac{Watts}{V \times I} \neq \cos \phi$ = Displacement factor X Distortion Factor
4.	Load current does not contain harmonics.	4.	Load current contains all ODD harmonics.
5.	Could be inductive or capacitive.	5.	Can't be categorized. As leading or lagging Loads.
6.	Resistive, Inductive or capacitive	6.	Usually an equipment with Diode and Capacitor.
7.	Zero neutral current if 1 Ph. loads are equally balanced on 3Ph. Mains (Vector sum of line current)	7.	Neutral current could be 2.7 times the line current even if 1Ph. loads are equally balanced on 3 Ph. Mains
8.	May not demand high inrush currents while starting.	8.	Essentially very high inrush current (20 time of I Normal) is drawn while starting for approx. One cycle.

EFFECTS OF HARMONICS ON NEUTRAL

In a 4-wire three phase system, the fundamental currents at any instant will always add up to zero in the neutral. However, the third harmonic of each phase is always in phase with those of the other two phases. As a result, rather than canceling each other (as is the case with the fundamental), they are additive and may well lead to serious neutral loading problems. As an example: a three phase system has 100 amperes load and each phase contains 30% third harmonic. The harmonic current flowing through the neutral will be three times. 30% of 100, or 90 amperes at the three times of the fundamental frequency (150 Hz for 50 Hz systems) Ref. current wave diagram.

Therefore, it is recommended to use neutral of minimum double the capacity since total load on the system in consideration of Linear loads and Non Linear loads. It is also advised to use single phase UPS/Loads wherever possible with individual neutral in place of using three phase UPS/Loads.

Due to the high frequency and skin effect the current flows on the other surface of the conductor and also to minimize neutral impedance, it is preferred to use number of conductors in parallel in place of single neutral conductor.

EARTHING

The system shall be earthed through conducting material suitable to carry the fault current. The minimum cross section of the earth conductor shall be calculated based on maximum current, which can flow at the time of short circuit/earth fault.

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