K Factor Ratings

The K-Factor rating assigned to a transformer and marked on the transformer case in accordance with the listing of Underwriters Laboratories, is an index of the transformer's ability to supply harmonic content in its load current while remaining within its operating temperature limits. A specific K-factor rating indicates that a transformer can supply its rated KVA load output to a load of specified amount of harmonic content. At present, industry literature and commentary refers to a limited number of K-factor ratings: K-1, K-4, K-9, K-13, K-20, K-30, K-40. In theory, a transformer could be designed for other K-factor ratings in-between those values, as well as for higher values. The commonly referenced ratings calculated according to ANSI/IEEE C57.110-1986 are as follows:

K-1: This is the rating of any conventional transformer that has been designed to handle only the heating effects of eddy currents and other losses resulting from 60 Hertz, sine-wave current loading on the transformer. Such a unit may or may not be designed to handle the increased heating of harmonics in its load current.

K-4: A transformer with this rating has been designed to supply rated KVA, without overheating, to a load made-up of 100% of the normal 60 Hertz, sine-wave, fundamental current plus: 16% of the fundamental as 3rd harmonic current; 10% of the fundamental as 5th; 7% of the fundamental as 7th; 5.5% of the fundamental as 9th; and smaller percentages through the 25th harmonic. The "4" indicates its ability to accommodate four times the eddy current losses of a K-1 transformer.

K-9: A K-9 transformer can accommodate 163% of the harmonic loading of a K-4 rated transformer.

K-13: A K-13 transformer can accommodate 200% of the harmonic loading of a K-4 rated transformer.

K-20, K-30, K-40: The higher number of each of these K-factor ratings indicates ability to handle successively larger amounts of harmonic load content without overheating.

Table 1 Gives example of K-factor loads.
Triplen harmonic currents are phase currents which flow from each of the phases into the fourth wire neutral and have frequencies in integer multiples of three times the 60 hertz base frequency (180Hz, 360Hz, 540Hz, etc). At each of these third multiple triplen frequencies, these triplen phase currents are in phase with each other and when flowing in the neutral as zero sequence currents, are equal to three times their RMS phase values. See Figure 2.

In a 3-phase, 4-wire system, single-phase line-to-neutral currents flow in each phase conductor and return in the common neutral.

Since the three 60 hertz currents are separated by 120°, when balanced they cancel each other. The measured resultant current is equal to zero. See Figure 2.

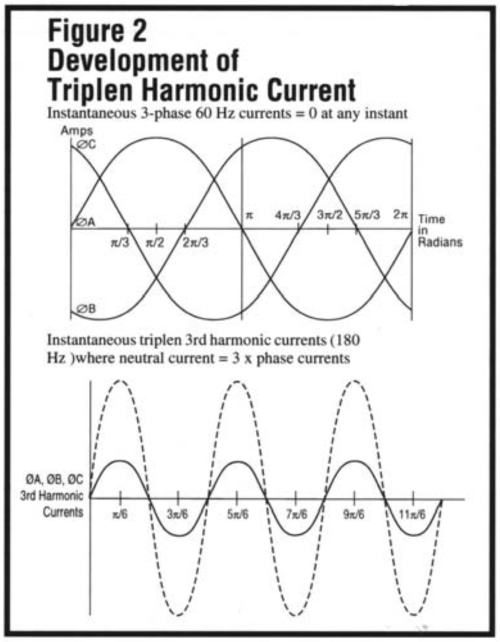

Figure 2 Development of Triplen Harmonic Current

Theory also states that for even harmonics, starting with the second order, when balanced the even harmonic will cancel in the common neutral.

Other odd harmonics add in the common neutral, but their magnitude is considerably less than triplens. The RMS value of the total current is the square root of the RMS value of the individual currents squared. As shown in Equation 2.

Equation 2

$$I_{Total} = \sqrt{I^2_{60Hz} + I^2_{180Hz} + I^2_{300Hz} + I^2_{420Hz} + \ldots}$$

where I = RMS

At any given instant, the 60 Hertz currents on the three-phase legs have a vector resultant of zero and cancel in the neutral. But, the third (and other odd triplen harmonics) on the phase legs are in phase and become additive in the neutral.

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