

19. Can neutral currents, such as the 3rd harmonic, be reduced by the use of 3rd harmonic blocking filters?

Some manufacturers are promoting the use of 3rd harmonic (180 Hz) blocking filters for the treatment of high neutral currents caused by non-linear loads such as personal computers. These devices are parallel L-C filters tuned to 180 Hz and are connected in the neutral of 4-wire systems between the transformer secondary and the neutral-to-ground connection. Their high impedance to the flow of 3rd harmonic current forces all connected equipment to draw current that does not contain the 3rd harmonic. Although their use will result in a significant reduction in 3rd harmonic current, it is achieved at the risk of rather severe consequences.

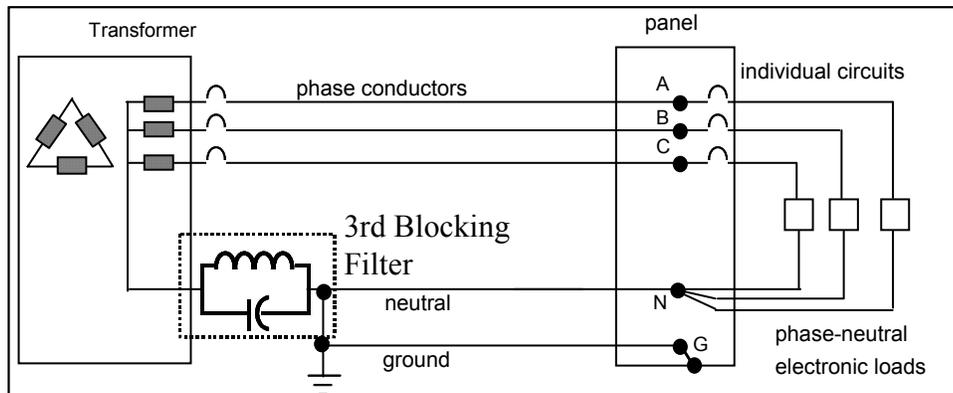


Figure 14: Typical installation of 3rd Harmonic Blocking Filter

Some reasons for concern are as follows:

1. The installation raises questions with respect to *NEC 2002* compliance. *NEC 250.30(A)(2)(a)* states that “a grounding electrode conductor for a single separately derived system ... shall be used to connect the grounded conductor of the derived system to the grounding electrode...” In addition, “the grounding electrode conductor shall be installed in one *continuous* length without a splice or joint...” [italics added. See *NEC 250.64(C)*]. If a simple splice connection is not allowed, then certainly the L-C circuit of the 3rd harmonic blocking filter should not be allowed either. Also, the installation results in an impedance grounded wye system rather than a solidly grounded system. The only reference in *NEC* that allows for the introduction of an impedance between the neutral and the grounding electrode is found in Section 250.36, High-Impedance Grounded Neutral Systems. However, these systems are permitted only at 480V and higher and only if they do not serve line-to-neutral loads. They also require the use of ground fault detectors. None of these requirements is met in the normal application of the 3rd harmonic blocking filter where the loads are primarily 120V, phase-to-neutral connected computer or other power electronic equipment.
2. Although tuned to 180 Hz, the L-C circuit will introduce some impedance at 60 Hz as well. The consequences are:
 - a. Line-neutral short circuit current will be reduced which will limit a circuit breakers ability to clear a line-neutral fault. This can be very dangerous because an uninterrupted fault (commonly referred to as an arcing fault) will often result in an electrical fire.
 - b. The neutral point at the transformers wye secondary can shift. This can result in 120V line-neutral voltages that rise and fall unpredictably as the load balance between the phases varies.
3. High impedance to the flow of 3rd harmonic current will produce voltage distortion in the form of flat-topping - a dramatic reduction in peak to peak voltage. This will:
 - a. Significantly reduce the ride-through capability of switch-mode power supplies (SMPS) since the DC smoothing capacitors will not be allowed to fully charge.
 - b. Reduce the SMPS DC bus voltage, thereby increasing the current demand and the associated I^2R losses. Component reliability will be reduced due to higher operating temperatures.
 - c. Often cause 1-ph UPS systems to switch to battery back-up.
 - d. Force connected equipment to operate without 3rd harmonic current – an operating mode for which they have not been intended or tested.

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At first, when loading is light, problems may not be extremely obvious. However, as the load increases, voltage distortion and flat-topping will also increase until problems do arise. Figure 2 shows the voltage waveform of a 3rd Harmonic Blocking Filter installation at a financial institution. Although neutral current was indeed reduced, it was achieved at the expense of a tremendous increase in voltage distortion. At 30%, the voltage distortion was 6 times the maximum limit of 5% recommended by IEEE std 519. In addition, the crest factor of 1.19 was 19% below the normal sinusoidal crest factor of 1.414. (For an explanation of the effect of voltage flat-topping on connected equipment, see Question 9).

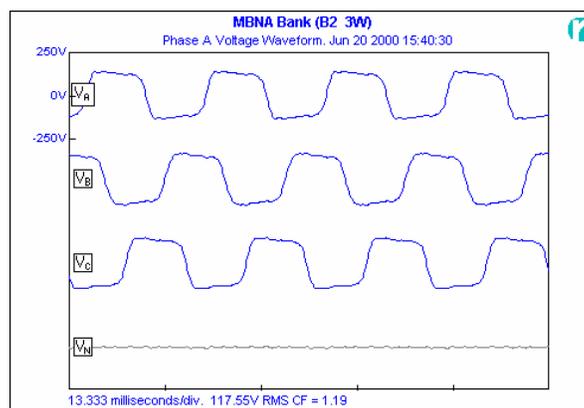


Figure 2: Voltage Flat-topping caused by 3rd Harmonic Blocking Filter

4. The 180 Hz L-C blocking filter requires the use of capacitors and it is well known that capacitors are less reliable than inductors and transformers. Failure of the capacitor or its protection could result in a very high impedance ground at the neutral over the full frequency range. This would have a dramatic effect on 60 Hz unbalance and fault currents.
5. At frequencies above the resonant point (180 Hz), the parallel L-C circuit becomes capacitive which could result in a resonant condition at some higher harmonic frequency.

A much better strategy for 3rd harmonic current treatment is the use of a parallel connected low zero sequence impedance filter such as the MIRUS Neutral Current Eliminator™ (NCE™). This device provides a lower impedance, alternate path for the flow of 3rd harmonic and other zero sequence currents, thereby off-loading the neutral conductor and upstream transformer. In addition, voltage distortion is decreased because the harmonic currents no longer pass through the transformer and cable impedance. For more information on the zero sequence filter, see Question 11.

References:

1. A. Hoevenaars, *3rd Harmonic Blocking Filters – Is the Cure Worse than the Disease*, IAEI News, Sept/Oct 2002, pp. 68 - 74