

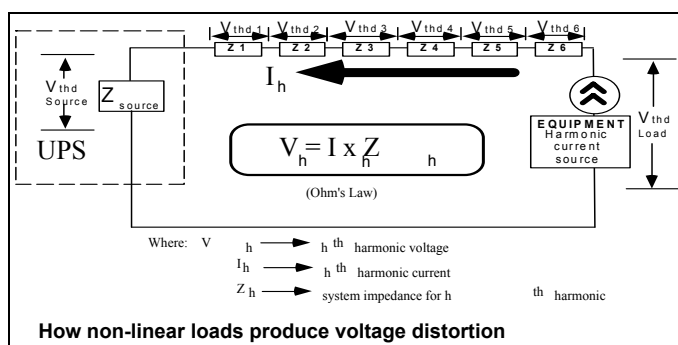
APPLICATION NOTE, H2-3



Using Harmony-2™ Downstream of UPS

Often the decision to buy an Uninterruptible Power Supply (UPS) for a critical load application, is made assuming that the UPS will resolve all power quality issues. This is almost true. A well maintained UPS from an established manufacturer should be effective against incoming power disturbances, including interruptions, sags, surges, spikes and frequency swings. But what about disturbances caused by the loads themselves, such as harmonics? Many UPS's are not only ineffective at handling them but, in fact, can contribute to making the problem even worse. This is primarily due to a combination of the voltage distortion resulting from the UPS's conversion of DC power to AC and the relatively high source impedance of most standard UPS units.

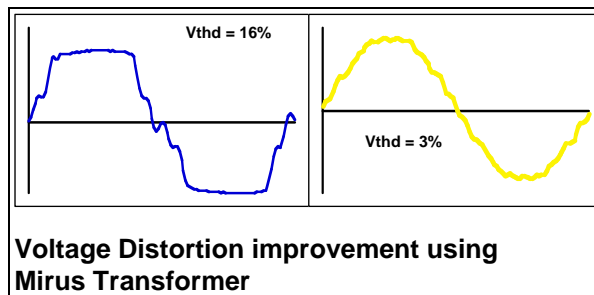
Most UPS units can provide a voltage waveform that is less than 5% distorted when servicing linear loads but many have trouble maintaining a low distortion level when faced with loads that are quite non-linear. Most of today's critical loads, such as computers, telecommunications equipment, and other electronic loads, are very non-linear in nature, generating significant amounts of harmonic currents. These harmonic currents will produce high voltage distortion downstream of the UPS as they interact with the distribution system impedance, including UPS source impedance. A voltage drop will develop at each harmonic frequency, the accumulative effect of which will produce a distorted voltage waveform. This distortion is most prevalent near the loads, since this is the point at which the distribution impedance is greatest (i.e.. source impedance + cable impedance + transformer impedance, etc.).



The **only** effective way of reducing this voltage distortion is by reducing the system impedance as seen by the harmonic generating loads. Mirus' approach to this challenge is to provide a lower impedance path for the principle harmonic currents, 3rd, 5th, 7th, 9th, etc., through the use of specialty transformers.

How Mirus Transformers reduce Voltage Distortion:

Mirus achieves its impressive results in reducing voltage distortion by treating the harmonic currents at the secondary of the transformer. Our patented two-fold approach, low zero sequence impedance combined with phase shifting, effectively treats all the principle harmonics, 3rd, 5th, 7th, 9th, etc. The low zero sequence impedance treats the triplen harmonics, 3rd, 9th, 15th, etc. while applying phase shifts of 30° and/or 15° treats 5th, 7th and 11th, 13th, respectively.



Unlike conventional and K-rated transformers, which rely on the innate characteristic that triplen harmonics will circulate in the primary winding of a delta-wye transformer, Mirus transformers are specially wound so as to achieve cancellation of the triplen harmonic flux at the secondary windings. This reduces the impedance at the secondary windings and prevents the triplens from circulating in the primary winding. The overall result is a more than 3 times reduction in the transformer's zero sequence impedance.

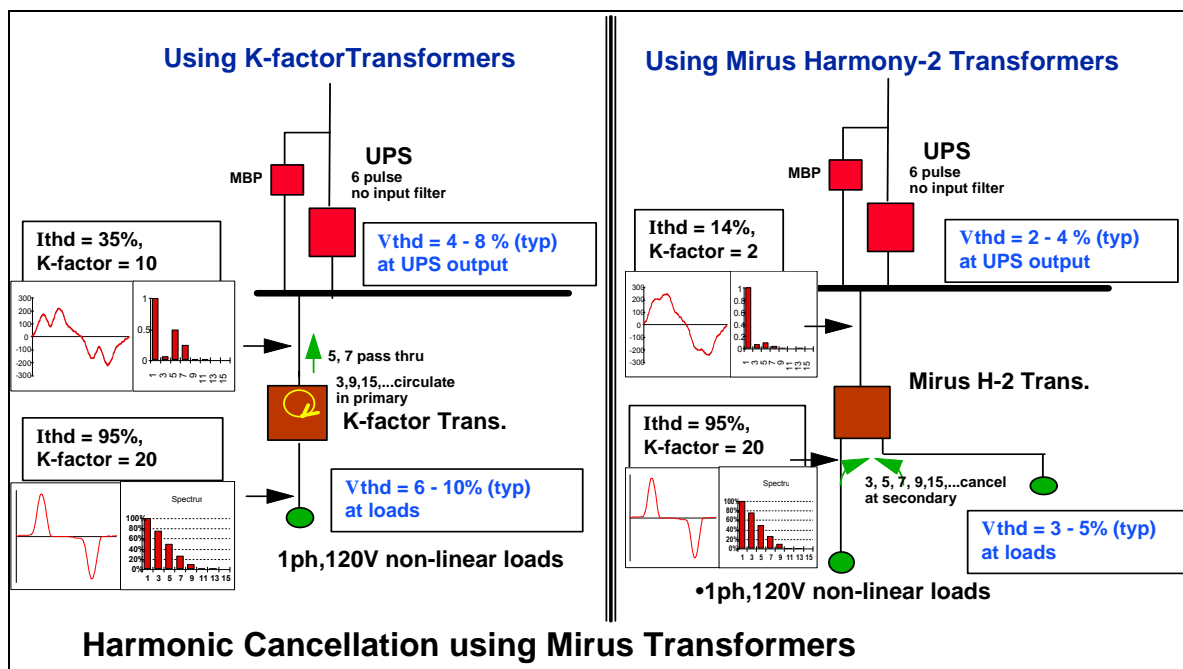
In order to reduce the system impedance on the 5th and 7th harmonics, the Mirus Harmony-2™ transformer is equipped with two secondary windings, phase shifted 30° with respect to each other. Since a 30° phase shift on

the fundamental 60 Hz frequency, will appear as a 180° phase shift on the 5th and 7th order harmonics, a cancellation effect is created between the 5th & 7th harmonics on each output. By canceling these harmonics at the secondary, they are not subjected to the primary side cable impedance and the high source impedance of the UPS.

If the 11th & 13th harmonics are substantial enough to require treatment as well, this can be accomplished on the primary side of the Mirus transformers. By alternating transformers with 15° phase shift on the primary windings with transformers with 0° primary phase shift, cancellation of the 11th & 13th harmonics is induced at the point of common coupling on the primary side. Although, when treating on the primary side, the transformer impedance and some of the primary cable impedance remains, voltage distortion is still significantly reduced by the fact that the UPS source impedance is eliminated.

By lowering the system impedance at all the principle harmonics, the Mirus Harmony-2™ transformer will produce a very significant reduction in the voltage distortion that results from today's non-linear loads. The figure below demonstrates the difference between using standard K-rated transformers and Mirus Harmony-2™ transformers in a typical critical load distribution serviced by a UPS.

Benefits:



1. Lower Voltage Distortion downstream of UPS (2 - 3 times improvement).
2. Improved power factor as seen at the UPS output.
3. Lower system losses

Related Products and Applications:

Mirus has a full line of harmonic mitigating transformers and in some applications our single, 3 or 4 output transformers are better suited. Please consult the factory for details. Harmonic distortion is also a serious concern on the **input** of a UPS supplied system, especially when a diesel generator is used as a back-up source to the Utility. Mirus Application Note #EL-1 describes how our ELIMINATOR™ line of specialty autotransformers can be used to cancel harmonic currents to improve power factor and voltage distortion at the generator output which will either free up capacity at the generator or allow for the installation of a smaller unit.