<Back to Questions>

6. What problems do non-linear loads and harmonics create?

Most power systems can accommodate a certain level of harmonic currents but will experience problems when they become a significant component of the overall load. As these higher frequency harmonic currents flow through the power system, they can create problems such as:

- Overheating of electrical distribution equipment, such as cables, transformers, standby generators, etc.
- Overheating of rotating equipment, such as electric motors
- High voltages and circulating currents caused by harmonic resonance
- Equipment malfunctions due to excessive voltage distortion
- Increased internal losses in connected equipment resulting in component failure and shortened lifespan
- False operation of protection equipment
- Metering errors
- Lower system power factor preventing effective utilization
- Voltage regulator problems on diesel generators
- Inability of automatic transfer switches to operate in closed transition

Harmonics overheat equipment by several means. For example, in electric machines and transformers, harmonic currents cause additional power losses by (i) increasing the eddy currents that flow in their laminated cores, (ii) through increased leakage currents across insulation and (iii) by producing skin effect in conductors. For additional information on how harmonics increase power losses and overheat transformers see Question 10.

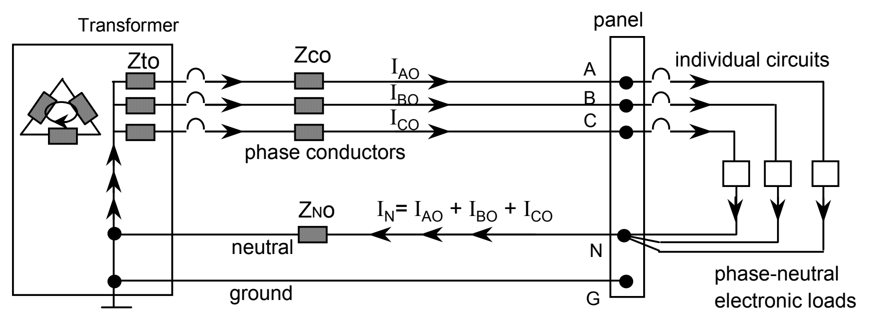

Figure 6-1: Zero sequence currents trapped in the transformer's delta winding

The incidence of hot transformers and neutral conductors has been especially common. Even under less than full load conditions, a transformer can run surprisingly hot. One of the reasons is its winding configuration. The overwhelming majority of distribution transformers are DELTA primary, GROUNDED WYE secondary. The delta winding has some undesirable characteristics when significant amounts of 3rd harmonic (and other zero sequence currents) are present on the load side. These harmonics return along the neutral conductor and are trapped in the primary DELTA winding where they circulate causing significant extra heating. They do not flow through to the primary system, but they also are NOT cancelled (Figure 6-1).

Since additional heating will reduce the life-span of a transformer, it must either be derated (not operated at its full nameplate rating), built to tolerate this additional heating (K-rated transformer) or designed to prevent the primary side circulating currents from being induced (harmonic mitigating transformer). A guide for derating has been proposed by CBEMA (Computer and Business Equipment Manufacturers Association) with the intent to provide users the ability to protect existing transformers which service non-linear loads. The relationship is as follows:

Derating Factor = (1.414 x RMS load current) / (PEAK load current)

Since many of today's multimeters can measure both peak and TRUE-RMS current, the derating factor can be quickly calculated. When a transformer feeds personal computers and other electronic equipment, typical values range from 0.5 to 0.7 meaning that the transformer should be loaded no more than 50 - 70% of its nameplate full-load rating to prevent damage due to premature aging.

The fact that harmonic currents create voltage distortion as they flow through the power system's impedance makes their impact even more serious. It is voltage distortion, not current distortion, that will affect the connected equipment on the power system. For more on how non-linear loads create voltage distortion and how this can affect connected equipment, see Questions 8 and 9.