

Ferroresonance Explained

by Jim Vaughn, CUSP, Atkinson Power

Ferroresonance is a complicated issue. It is important to familiarize crews with ferroresonance because as the number of URD systems installed increases and as systems age, the incidence of ferroresonance increases and so does the threat to equipment, service reliability and, most importantly, the safety of workers and customers.

Ferroresonance is a rare condition most likely to occur with three-phase pad-mount delta-connected transformers. Not nearly as often, ferroresonance has also been documented in wye-wye transformers and in aerial three-pot banks served by long-dedicated aerial circuits.



When ferroresonance does occur in a transformer, high voltages three to five times the rated primary can appear on the primary, in the core and on the secondary.

Oil heats to temperature extremes that can be reached in minutes, blowing out of vents and bubbling paint on top of the transformer. Surge arrestors – not designed to clamp sustained over-voltages – can cook to destruction, sometimes fragmenting during failure.

After the first pothead fuse was closed to this feedthrough three-phase transformer, it began to rattle furiously. Seconds later an uncapped bushing flashed over.

The rise in primary also raises the secondary voltage, blowing up meters sometimes like bombs. Other times, purely coincidental but perfect conditions create low-level ferroresonance that can

boil the life out of a transformer with barely a whimper. I know of a case where a 1000-kVA transformer was replaced three times in five years before the utility realized a low-level resonant circuit – yes, without an open phase – was killing the transformer every night when the commercial building load dropped to about 6 percent of the transformer rating during kWh-saving night lights and low AC.

URD cables are capacitors; transformer coils are magnetic inductors. Three things must happen in order for resonant circuits to occur. There must be a capacitive reactance and inductive reactance of almost equal value in series with each other, and the inductor must have no or very little load. The most likely condition for this event is a three-phase transformer fed by a long underground circuit. The most dramatic events usually begin when a pothead fuse is opened or blown, allowing a still energized primary cable (capacitance) to be more or less “in series” with a coil (inductance). If the series-connected phase-to-coil connection is allowed to remain energized and loading on the secondary of the transformer is low, or the customer’s mains are open, there is no impedance in the circuit and current is free to flow. In testing, loading of the secondary above 20 percent was sufficient to prevent resonance. The first indication of the condition is usually a very loud rattle of the transformer (magnetostriction in the laminated core)

often described as shaking a coffee can full of marbles. The sound is wicked enough that those who have heard it, including me, did not stand around to see what was going to happen next.

In two cases I have been involved with, both were amorphous core wye-delta pad-mounted three-phase transformers. One was 1,700 feet of 1/0 to a 1000 kVA, the other 2,000 feet of 1/0 primary to a 1500-kVA pad-mount. This is not a formula for determining the potential for ferroresonance, but an example of what conditions were present when ferroresonance occurred in these particular cases.

The best way to avoid suspect resonant circuits is to avoid opening three-phase transformers one phase at a time from potheads or lateral taps. Some utilities are using an AB switch to isolate the coil before switching potheads. Opening loads by elbows tends to isolate cable capacitance. Other corrective methods include shortening the primary run to change capacitance or replacing transformers with different inductive impedance values.

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Ferroresonance damages transformers, lightning arresters and other distribution equipment. This article tells us three conditions are necessary for ferroresonance to occur:

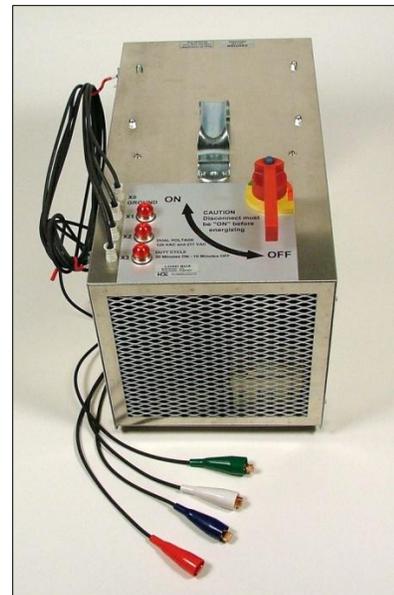
1. Three phase transformers with no load or lightly loaded.
2. Underground cable.
3. Single phase switching-phases switched one at a time such as when using cutouts.

The writer tells us ferroresonance can be avoided by *shortening the primary run to change capacitance or replacing transformers* but these solutions are not always easy or even possible.

An easier solution is using the HDE Load Box. The Load Box connects to the secondary side of the three phase transformer and adds enough load to prevent ferroresonance.

The HDE three phase automatic Load Box is an easy and portable solution and stops ferroresonance before it can occur.

For more information on the Load Box, visit www.HDElectricCompany.com or contact HDE at (847)473-4980.



HDE LB-5 Load Box