PSCAD Cookbook

Ferroresonance

Written for v4.5
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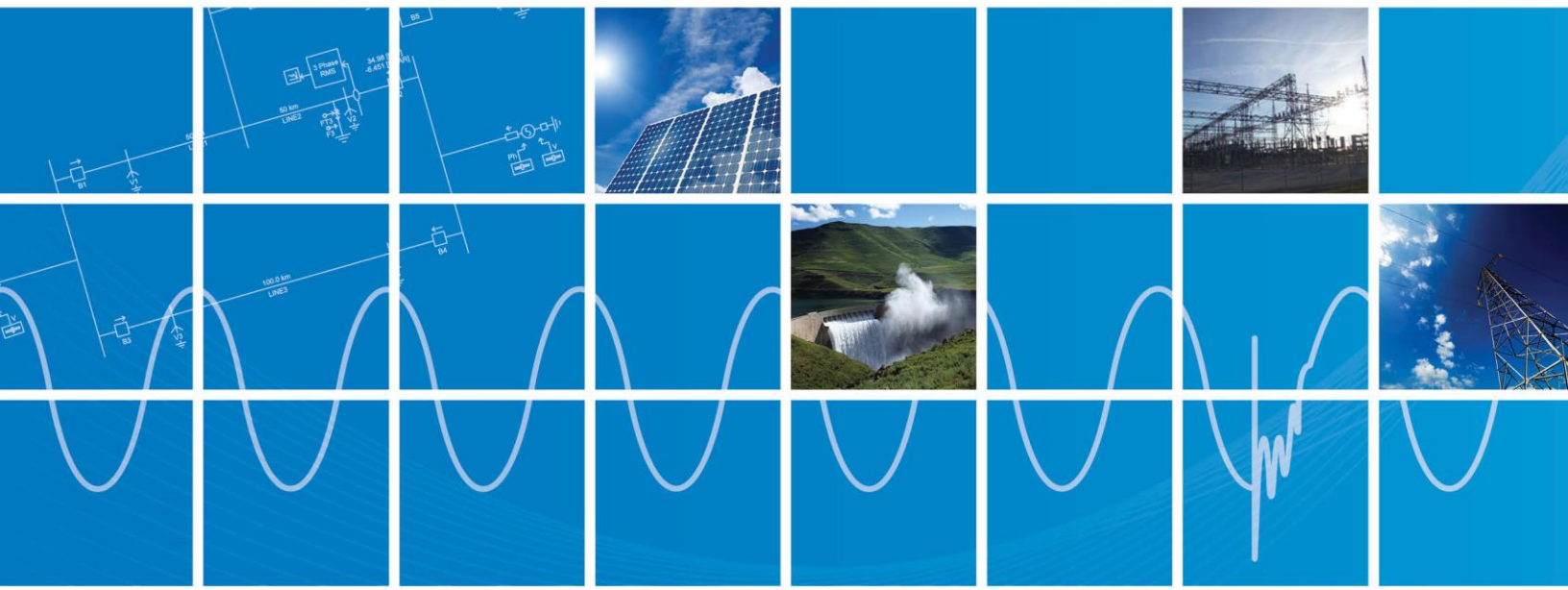
May 08, 2018



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4. Ferroresonance Studies

4.1 Ferrosonance

Motivation

Ferroresonance is a serious resonant problem at the system frequency. It could lead to sustained (i.e. long duration) overvoltage, unlike normal switching transients which generally get damped out rapidly.

The circuit in Figure 1 illustrates what could happen if a resonant condition occurred in a network. The capacitance may come from installed series compensation capacitors, capacitance of transmission lines, breaker grading or even the natural (i.e. stray) capacitance of large equipment. The inductance would most likely be from a saturable transformer. The impedance of the network is $Z = j\left(\omega L - \frac{1}{\omega C}\right)$. If the resonant condition in which $\omega L = \frac{1}{\omega C}$ is satisfied at the system frequency, we would begin to see large currents and voltages in the system. The reason is that with the resonant condition, $Z \approx 0$, and we have $I = \frac{V}{Z}$, which can be very large. With the large current, equipment will also see a large voltage across it since $V_{equipment} = Z_{equipment} I$.

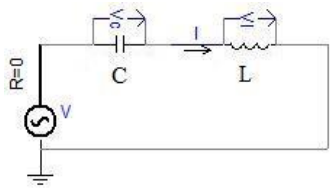

Figure 1: Resonant Condition

System Overview

A ferroresonant condition that might arise in a system is depicted in Figure 2. In this system, a breaker open signal is issued to breakers LINEA, LINEB and LINEC, but breakers LINEA and LINEC are stuck closed and only LINEB opens. Because of this anomaly, there exists an LC loop in the system that satisfies the ferroresonance condition (i.e. the transformer saturates). Once the resonant condition is reached, the high voltage across the transformer can cause the transformer to saturate deeper. Detailed simulations are required to understand the behaviour of the system under this highly nonlinear event.

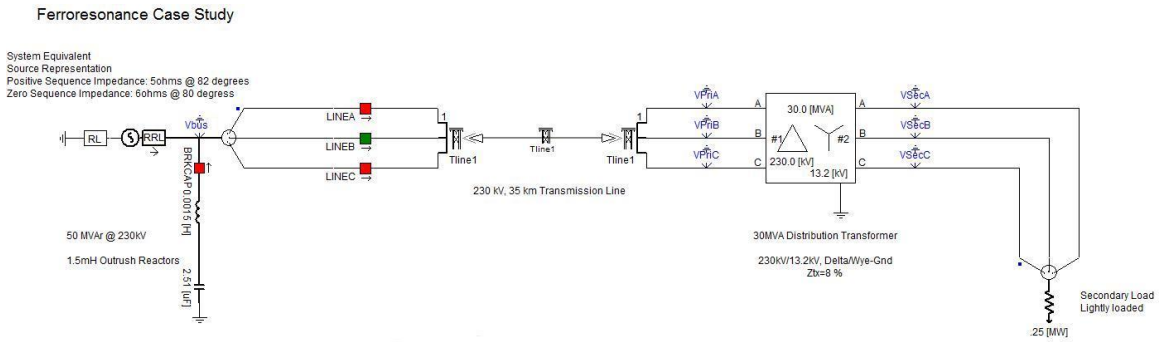

Figure 2: Case Circuit

Simulation Results

Figure 3 shows the phase voltage (Phase B) waveforms on the primary side of the delta-wye transformer. At 300 ms, the breaker is opened. The top graph in Figure 3 shows the voltage if saturation is disabled in the transformer. The bottom graph takes transformer saturation into account and shows that voltages may rise to 4 PU.

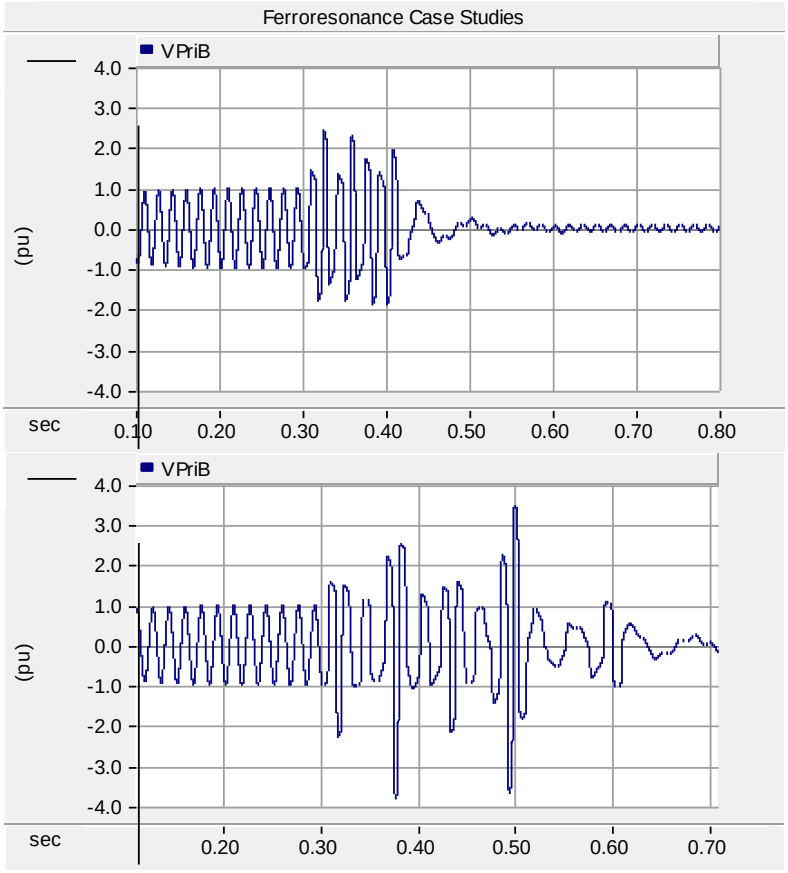

Figure 3: Simulation Results

The ferroresonant conditions are normally satisfied when there are abnormal switching conditions or iron core saturation of the transformer. The system losses and system load will have a damping effect on the transients.

In the accompanying case, observe the effects the following will have on ferroresonance:

- Change the load
- Change the transformer losses
- Change the transformer magnetizing current and transformer saturation characteristics

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Refer to PSCAD case: Ferroresonance_01.pscx

DOCUMENT TRACKING

Rev.	Description	Date
0	Initial	01/Jun/2013
1	Update to New Brand Guidelines	08/May/2018