Investigation of Ferroresonance Phenomena in Electric Power Systems

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This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for the degree of Master of Science in Electrical Power and Machines Engineering.

The work included in this thesis was carried out by the author in the department of Electrical Power and Machines Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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Acknowledgment

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Abstract

Ferroresonance is one of the most destructive and longest known power quality disturbances in the history of AC power systems. Such phenomena occur in a power system during transient conditions, Transmission line faults and unsymmetrical switching events on some lines in the presence of lightly loaded transformers. The phenomenon of a ferroresonance is a name given to a situation where the nonlinear magnetic properties of iron in transformer interact with the capacitance existing in the electrical network.

Many cases of ferroresonance have been reported in power systems over the years. In recent years the number of ferroresonance incidents have increased due to network complexity and improved equipment efficiency (low losses systems). The main feature of this phenomenon is that more than one stable steady state response is possible for the same set of the network parameters. The response is highly dependent on the initial operating conditions, loads and the circuit parameters. Ferroresonance has endured many decades of intense research due to its highly mysterious nonlinear behavior, challenges in prediction and ongoing need for mitigating the dangerous oscillations still exist. The occurrence of ferroresonance is usually marked with large overvoltages and overcurrents with highly distorted waveforms which can cause irreparable damage to power system components.

In this study, the ferroresonance phenomenon is investigated both analytically and experimentally. This study considers a single phase transformer connected in series with capacitor and fed from variable voltage AC power supply at a system
frequency of 50 Hz and 100 Hz. The study verified the effect of supply voltage, capacitance value and system frequency on the onset of ferroresonance phenomena. Also, the influence of resistance on the ferroresonance phenomena is investigated by connecting two values of resistances individually; small resistance of 3 Ω and large resistance of 15 Ω in series with the capacitor and the low tension side of the transformer. The study discusses the ferroresonance phenomena and its consequences on apparatus. It also shows the ferroresonance circuit and the conditions when the operating point moves from the 1st quadrant to the 3rd quadrant of the saturation curve plot where the phenomenon occurs. The experimental work has required the determination of the transformer under study parameters. The No load test, Short circuit test referred to H.V. Side and resistance measurement test were performed.
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