STUDY ON THE NON LINEAR CHARACTERISTIC OF POWER TRANSFORMER AND THEIR EFFECT FERRORESONANCE

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ABSTRACT

Ferroresonance can occur in electrical power system and consequently can cause damage such as due to voltage transformer overheating or power transformer overvoltages. This study involves simulation work to simulate various conditions under which ferroresonance can occur in typical extra high voltage substations. The ATP-EMTP simulation program was used to model various power system components and simulate the ferroresonance phenomena. The effects of the non-linear characteristics of power transformers are also studied. Methods to prevent the ferroresonance conditions from occurring and hence avoiding equipment damages and losses were also proposed based on the simulation work.

ABSTRAK

Feroresonan berlaku ke atas sistem kuasa elektrik yang boleh menyebabkan kerosakan pada sistem tersebut. Contohnya kejadian pemanasan lebihan pada pengubah voltan ataupun voltan lampau pada pengubah kuasa. Kajian ini melibatkan kerja simulasi bagi pelbagai keadaan yang boleh berlakunya feroresonan pada pencawang elektrik EHV. Program ATP-EMTP merupakan satu program simulasi yang berkeupayaan untuk menghasilkan pelbagai model komponen sistem kuasa dan seterusnya melakukan simulasi ke atas sistem. Kajian simulasi ini melaporkan kesan sifat tak lelurus keluli pengubah kuasa terhadap feroresanan dan kaedah untuk mengelakkan berlakunya feroresonan. Justeru itu, kerosakan dan kerugian komponen dapat dihindarkan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A power quality is a term used to describe electrical power that motivates an electrical load and the load's ability to function properly with that electric power. With a poor power quality, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor power quality.

As a general statement, any deviation from normal of a voltage source (either DC or AC) categorized as a power quality issue. Power quality issues can be high-speed events such as voltage impulses / transients, high frequency noise, wave shape faults, voltage swells and sags and total power loss. Power quality issues will affect each type of electrical equipment differently. By analyzing the electrical power and evaluating the equipment or load, we can determine if a power quality problem exists.

Power quality problems manifest themselves in variations in the voltage has been obtained. This variation can be in the form of transients due to switching or lightning strikes, sags or swells in the amplitude of the voltage, a complete interruption in the supply, or harmonic distortion caused by non-linear loads in the system which may likely lead to the occurrence of ferroresonance.

1.2 Objective

The main objectives of this project is to simulate the ferroresonance event on extra high voltage substation power transformer based on parameters, features, components and arrangements of the substation power system. An alternative Transient Program- Electromagnetic Transient Program (ATP-EMTP) will be used to carry out the simulation in order to study the phenomenon and therefore to determine methods to minimize or reduce the risk of ferroresonance to power transformers.

1.3 Scope of Work

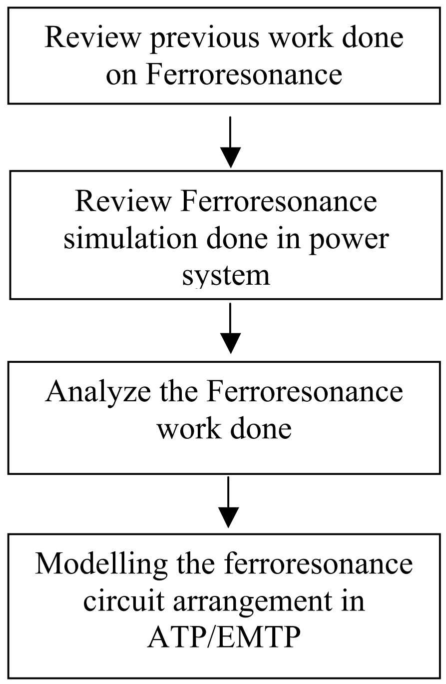
The main scope of this project is to simulate the various conditions of ferroresonance, which include:

i. To prove or otherwise that ferroresonance can occur at 400kV double circuit substation;
ii. To identify the effect of magnetization characteristic of power transformer on ferroresonance;

iii. To identify method to minimize the impacts of ferroresonance on power transformers.

1.4 Project Flow Chart

To solve the problem, one has to first study the problem and come up with the process flow chart, which will guide the simulator throughout the project. It is also to give the simulator the basic overview of the system and what is required before simulations be completed. The flow chart of this project is as shown in Figure 1.1.



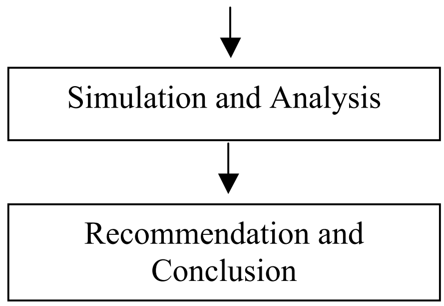


Figure 1.1: Project Flow Chart

1.5 Organisation of Thesis

Chapter 2 illustrates previous work done related on ferroresonance phenomenon in voltage transformer and power transformer. Besides, it is also includes some techniques for avoiding or mitigating ferroresonance. Chapter 3 describes the basics of ferroresonance, characteristics and types of ferroresonance. Chapter 4 describes the methods that are used for the simulation. Therefore, all information related the simulation is explained in detail with the operation. Chapter 5 presents the circuits that were used in the simulation and explains how the simulations techniques are implemented. Lastly, chapter 6 describes the conclusion and recommendation that is related to the project done.

List of References

1. Zia Emin,, Yu Kwong Tong.(2001). Ferroresonance Experience in UK: Simulations and Measurements IPST '01 - Rio de Janeiro, Brazil, June 24-28,Paper 006.2
2. Y K Tong (1997) NGC Experience on Ferroresonace in Power Transformer and Voltage Transformer on HV Transmission Systems. IEE
3. David A. N. Jacobson, Examples of Ferroresonance in a High Voltage Power System Member, IEEE
4. Electrical Electrical Engineering Tutorials: Ferroresonance- Introduction, Classification and Characteristic 20 March, 2007
5. Technical Buletin — 004a. Ferroresonance, (2002)
6. ATPDRAW version 3.5 for Windows 9x/NT/2000/XP Users' Manual (2002)
7. Juan A. Martinez-Velasco. Bruce A.Mork, Transformer Modeling for Low Frequency Transient- The State of the Art IPST 2003, International Conference on Power Systens Transients.
8. Hans.K. Hokaidan, Laszlo Pikler, Bruce A. Mork, New Features in ATPDraw Version 3.5. EEUG Meeting 9-10th Hungary
9. Charalambos Charalambous, Z.D. Wang, Jie Li, Mark Osborne and Paul Jarman.(2007)Validation of a Power Transformer Model for Ferroresonance with System Tests on a 400 kV Circuit. IPST
10. B. Peter Daay. Ferroresonance Destroy Transformers (1191). IEE
11. M.R Iravani, Chair, A. K. S. Chaudhary, W. J. Giesbrecht, I. E. Hassan, A. J.F.Keri, K. C. Lee,J. A. Martinez, A. S. Morched, B. A. Mork, M. Parniani, A. Sharshar, D. Shirmohammadi, R. A. Walling, and D. A. Woodford.(2000) Modeling and Analysis Guidelines for Slow

12. Transients—Part III: The Study of Ferroresonance. IEEE Transactions, Vol 15. No.1
13. S. Mozaffari, M.Sameti, A.C.Soudack. Effect of initial conditions on chaotic ferroresonance in power transformers. IEE no. 19971459
14. ZhuZhu Xukai, Yang Yihan, Lian Hongbo, Tan Weipu.(2004) Study on Ferruresonance due to Electromagnetic PT In Ungrounded Neutral System . IEEE
15. Bernard C. Lesiutre, Jama A. Mohamed, Aleksandar M. Stankovic, (2000) Analysis of Ferroresonance in Three-Phase Transformer.IEEE Percon
16. S. Mozaffsri, M. Samet, A.C Soudack. (1997) Effect of Initial Conditions on Chaotic Ferroresonance in power transformer. IEE .Proceeding online no. 1971459
17. Bruce A.Mork., Parameters for Modeling Transmission Lines and Transformers in Transient Simulations. (2001) IEEE
18. Marta Val Escudero,Ivan Duduryah, Miles Redfm.: Understanding Ferroresonance ESB International, Ireland
19. P. Ferracci: Ferroresonance, Cahier Technirue 190 (1998). Group Schneider.
20. Dr. D.A.N. Jacobson , Dr. R. W. Menzies (2001). Investigation of Station Service Transformer Ferroresonance in Manitoba Hydto's 230kV Dorsey Converter Station. IPST