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The analysis of lightning overvoltage by EMTP for lightning protection design of 500 kV substation / Noor Azila Khazaimah.

**THE ANALYSIS OF LIGHTNING OVERVOLTAGE BY EMTP FOR
LIGHTNING PROTECTION DESIGN OF 500 kV SUBSTATION**

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MAY 2006

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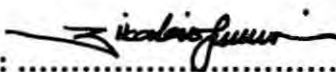
**This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree
of Bachelor In Electrical Engineering (Industrial Power)**

Fakulti Kejuruteraan Elektrik

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May 2006


“I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the Degree of Bachelor in Electrical Engineering (Industrial Power)”

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Date : 3/5/2006

“ I declare that this thesis is the result of my own research except as cited in the references”

Signature : 

Name : **Noor Azila Binti Khazaimah**

Date : *3 / 05 / 06*

DEDICATION

To my beloved father Khazaimah @ Ahmad Khushairi b. Hj Abbas and my beloved mother Hasni bt Mohd Hassan, to my sisters Noor Syazlin and Nur Afiqah for all their support throughout my college studies. Last but not least to a special person in my life who encourage and motivate me to work harder into achieving my goals.

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Not forgetting to my beloved family for their moral and financial support. Thank you for believing in me and your undoubted love and encouragement had kept me going.

Thank you all.

ABSTRACT

In order to meet increasing power demand, the 500 kV power systems are under consideration in some regions of Middle Asia country. As the power system voltage becomes higher, the cost for the power system insulation greatly increases. The 500 kV transmission systems will become the basis of power system in its country and they require much higher system reliability. Consequently, by the methods of limiting overvoltages effectively, a reasonable insulation design and coordination have to be accomplished. In order to determine the various factors for the insulation design, the EMTP (Electro-magnetic transient program) is used for the magnification of transient phenomena in the planned network. In this project, there are explanations about the simulation results of lightning overvoltages by EMTP of 500 kV transmission line. To get the reliable results, the multi-story tower model and EMTP/TACS model were introduced for the simulation of dynamic arc characteristics. From the simulation, the effect of the direct lightning stroke to the transmission line model can be observed. The observations are done by analyzing and comparing the waveform characteristic of the simulation result when the lightning stroke model is applied at the different point of the transmission line model. The peak value of the overvoltage varies at when the lightning stroke model is applied at the different point of the transmission line model.

ABSTRAK

Untuk memenuhi peningkatan terhadap permintaan kuasa, sistem kuasa 500 kV sedang dipertimbangkan di sesetengah negara-negara Asia Tengah. Peningkatan voltan sistem kuasa, menyebabkan kos bagi sistem perlindungan sistem kuasa juga meningkat. Sistem talian penghantaran 500 kV akan menjadi asas kepada sistem kuasa di negara tersebut dan negara itu perlulah mempunyai tanggungan sistem yang lebih tinggi. Oleh itu, kaedah menghadkan voltan lampau secara efektif, rekaan sistem perlindungan yang bersesuaian dan koordinasi sistem perlindungan perlulah dilakukan. Untuk menentukan pelbagai faktor bagi mereka sistem perlindungan, EMTP (Electro-magnetic Transient Program) digunakan untuk perbesaran fenomena fana dalam plan rangkaian. Dalam projek ini, terdapat penerangan tentang keputusan simulasi voltan lampau kilat oleh EMTP bagi talian penghantaran 500 kV. Untuk mendapatkan keputusan yang baik, model menara "multi-story" dan model EMTP/TACS diperkenalkan untuk tujuan simulasi ciri-ciri dinamik arka. Kesan voltan lampau akibat dari panahan kilat ke atas model talian penghantaran dapat diperhatikan daripada simulasi yang dijalankan. Pemerhatian dilakukan dengan menganalisa dan membandingkan graf-graf yang diperolehi daripada simulasi dengan meletakkan model panahan kilat pada tempat yang berbeza pada model talian penghantaran. Dapat diperhatikan bahawa nilai voltan lampau berbeza apabila diletakkan di tempat yang berlainan.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Lightning current which come to the power system can be assumed into two cases; one is direct lightning stroke from the power line and the other is back flashover of transmission tower by the lightning stroke on top of the tower. When a thunder cloud directly discharges onto transmission line tower or line wires it is called direct stroke. Sometimes, when a direct lightning stroke occurs on a tower, the tower has to carry a huge impulse current. If the tower footing resistance considerable, the potential of tower rises to a large value, steeply with respect to the line and consequently a flashover may take place along the insulator strings. This is known as back flashover. In this project, the effect of direct lightning stroke to the power system has been analyzed.

The lightning phenomenon produces the traveling wave and overvoltage in the power systems. This voltage will damage the transmission line and the connected device. It is necessary to analyze and predict the overvoltage for the design of protection systems. This project describes the analysis of overvoltage which occurred in the power system. The EMTP program has been used to study the variation of overvoltage at the transmission line.

1.2 Project Objective

The aims of this project are as follows:

1. To design 500 kV transmission line by using EMTP
2. To obtain the suitable parameter for modeling overhead transmission line for 500 kV power system.
3. To observe the effect of lightning overvoltage of 500 kV transmission line due to direct strike to the power line
4. To analyze the characteristic of the lightning overvoltage varies by the distance of the lightning strike.

1.3 Project Scope

This project, is concentrated on the protection scheme for 500 kV in which considering:

1. Lightning current assumption
2. Surge/ lightning model
3. Transmission Line
 - a) Transmission tower
 - b) Tower Footing Resistance

1.4 Problem Statement

Lightning has always been a source of disturbance for users of electricity, yet the fairly recent and growing demand for quality electrical systems (reliability, availability, continuity of service, etc) must be taken into account, as well as the permanent necessity to minimize the costs of production and the use of electrical power. For this project the main problem which be taken into account are :

1. To design the overhead transmission line with suitable parameter data for 500 kV power system.
2. The knowledge of the lightning parameters which are usually incomplete. These limitations can partially be overcome by performing a parametric study that could detect those parameters for which an accurate knowledge is required.

1.5 Methodology of the Project

In order to solve the problem that are stated above, the methodology for this project are carried out as follows:

1. Understand the literature review
2. Lightning current assumption
3. Transmission tower model
4. Tower footing resistance
5. Transmission line model
6. Model validation
7. Simulate the complete model by using EMTP
8. Analyze the result of simulation

1.6 Literature Review

Literature study is done for the purpose of learning as much as possible about this project in term to achieve the objective of the project.

J.W.Woo; et al., 2005 [2], This article describes on the outline of lightning analysis model which include how to assume the current, the model that should be used in simulation to get the approximate result, how to make a diagram for lightning surge analysis and the discussion of the result of simulation by using the EMTP.

ATPDRAW version 3, User Manual, TR A4389, EFI, Norway, 1996 [1]. This reference is about the ATP (Alternative Transient Program) which is one of the most widely used universal program system for digital simulation of transient phenomena of electromagnetic as well as electromechanical nature in electric power system. It also describe about the EMTP application, which can be used for lightning overvoltage studies, switching transient and fault, machine modeling and etc. Besides, it also explains on how to use the program to simulate the model/circuit. In this project, the chapter which be concentrate is 'Using the integrated LCC object for line/cable modeling'. There are many models which can be used for the study but in this project the model that will be used is Bergeron (K.C.Lee and Clarke).

High Voltage Engineering, Third Edition, MS Naidu, V Karamaju, MC Graw Hill, International Edition 2004 [5]. This book describe about the phenomenon of the lightning. It also include about the parameter and characteristic of lightning stroke, protective devices which suitable for the overvoltage and the insulation coordination on high voltage power system. This book is used to understand the theory of the project or in other word the project background. Its also very useful to know the characteristic of the lightning stroke and which insulation is suitable to be the protective device.

Electrical Machines, Drives And Power System, Sixth Edition, Theodore Wildi, Professor Emeritus, Laval University, Prentice Hall, Pearson Educational International [6]. This book is used to understand the theory of the project. The book describe about lightning stroke, lightning arrester, the characteristic that should be considered to design the protection devices for lightning overvoltage which are the BIL (Basic Insulation Level), the insulation characteristic and the coordination of the insulation.

Akihiro AMETANI; et al., 2005 [3] This journal describe how to design a tower of overhead transmission line for back-flashover analysis using EMTP.

Juan A. Martinez-Velasco, Member, IEEE, Ferley Castro-Arnada, Student Member, IEEE; 2005 [4]. From this journal, there are explanations on how to select the tower structure and the suitable parameter for the structure.

1.7 Overview of the Thesis

Chapter 1 : Introduction

This chapter briefly explains the lightning characteristic and type of lightning strike at the power system. It then describes the objectives, scope of the project, problem statement and literature review that is done in order to do this project.

Chapter 2 : Fundamental Behind the Project

The explanations of the software that are used in this project are described in this chapter which is EMTP (Electromagnetic Transient Program). It also includes the explanation of the characteristic of the lightning strike and the characteristic of the transmission line that are suitable for lightning studies. At the end of the chapter, tells the insulation that are used to protect the electrical apparatus at the power system against the lightning stroke.

Chapter 3 : Methodology

This chapter, introduces the construction of the lightning stroke model, transmission line model, transmission tower model, tower footing resistor model and the source that are used at the transmission line. At the end of this chapter, the validation of the model is shown.

Chapter 4 : Result and Analysis

The simulation result of the project is shown in this chapter. It also included the analysis of the simulation result by comparing the effect of the lightning stroke at transmission line by the distance from the receiving area.

Chapter 5 : Discussion

This chapter discusses the problem and constraint while doing this project.

Chapter 6 : Suggestion

This chapter, discusses on how to solve the problem and what should be done to improve this project in the future.

Chapter 7: Conclusion

Summing up the characteristic of the lightning stroke that strike at the transmission line.