ANALYSIS AND SIMULATION OF LIGHTNING BACKFLASHOVER FOR 132kV TRANMISSION LINE USING PSCAD

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Bachelor of Electrical Engineering (Industrial Power)
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A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

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MAY 2010

I declare that this report entitle "*Analysis and Simulation of Lightning Backflashover For 132kV Transmission Line Using PSCAD*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is no concurrently submitted in candidature of any other degree.

Signature :..

Name : ...Rashidah Bt Mohd Deraman

Date : 10/5/2010 ....

" I hereby declare that I have read through this report entitle "*Analysis and Simulation of Lightning Backflashover For 132kV Transmission Line using PSCAD*" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : ....

Supervisor's Name : ....Puan Junainah Bt Sardi...........

Date : ....11/5/2010..

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I would also like to thanks Tenaga Nasional Berhad, Ayer Keroh for their corporation in supplying the relevant data and information. I would also like to express my special thanks and appreciation to all the lecturers, technicians and friends who directly and indirectly has been involved in helping, sharing knowledge, guidance, and support in completing this project.

Finally yet importantly, I would like to give a special and greatest thank to my parents and family for their moral support, understanding, motivation and patience, in which without their support and love I may not be able to complete this project.

May Allah S.W.T. reward you all with the best in this world and here after.

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ABSTRACT

Lightning has been concern to power system researcher as it can cause damage to electrical equipments and overvoltage at transmission line. Although, the overhead ground wire has been located at the transmission line to minimize the number of lightning strike that terminates on the phase conductor, the backflashover still can occur and cause problems to transmission line. This project will focuses to determined overhead transmission line backflashover rate and investigate the influence of line parameter to backflashover rate when subjected to lightning. Backflashover simulation and analysis will be done using Power System Computer Aided Design (PSCAD) software. Sample of case 132kV transmission line data was taken from Tenaga Nasional Berhad, for the purpose of backflashover and analysis simulation. A initial part of the studies is the modelling of transmission line components such as insulator coordination, lightning, tower, and tower footing resistance. Besides that, effects of line parameter such as ground resistance, soil resistivity and number of shield wire to lightning performance of transmission line in term of BFR were investigated. These entire models are verified using an accurate analysis by previous researchers. The results were analyzed and will be discussed based on IEE Guide, CIGRE and previous results obtain by other researchers. The significant of this project is it can be a guideline to the transmission line designer in designing the reliable transmission line and improved the performance of transmission line.

ABSTRAK

Kilat telah menarik perhatian pengkaji sistem kuasa untuk mengkaji tentangnya. Ini kerana, kilat merupakan faktor utama yang boleh menyebabkan kerosakan kepada perkakas-perkakas elektrik dan terjadinya lebihan voltan terutamanya pada talian penghantaran. Walaupun wayar pelindung telah dipasang pada talian penghantaran untuk menangkap panahan petir yang terkena pada fasa konduktor, namun pemercikan api tetap berlaku dan ini menimbulkan masalah pada talian penghantaran. Fokus utama projek ini adalah mencari kadar pemercikan api pada talian penghantaran dan mengenal pasti parameter- parameter talian penghantaran terhadap kadar pemercikan api semasa kilat. Simulasi dan analisis dijalankan dengan menggunakan perisian PSCAD. Satu sampel talian penghantaran telah diambil dari Tenaga Nasional Berhad bagi tujuan simulasi ini. Bahagian terpenting dalam kajian ini adalah komponen-kompenan talian penghantaran seperti koordinasi penebat,model kilat, menara dan rintangan kaki menara. Selain itu, kesan parameter talian seperti rintangan kaki menara dan kerintangan tanah serta bilangan wayar pelindung terhadap prestasi kilat turut dikaji. Semua model yang digunakan telah dikenalpasti ketepatan dan kesahihan berdasarkan analisis-analisis penyelidik terdahulu. Butir-butir khusus simulasi ini akan dianalisis dan dibincangkan berdasarkan ulasan dan keputusan yang telah dilakukan oleh penyelidik terdahulu. Projek ini dijalankan bertujuan untuk menjadi salah satu sumber rujukan kepada pereka talian penghantaran untuk meningkatkan prestasi pelindung kilat.

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LIST OF ABBREVIATIONS

AC	-	Alternating Current
ACSR	-	Aluminum Conductor Steel Reinforced
SF	-	Shielding Failure
BF	-	Backflashover
BFR	-	Backflashover Rate
BIL	-	Basic Lightning Insulation Level
CB	-	Circuit Breaker
CFO	-	Critical Flashover
LIPL	-	Lightning Impulse Protective level
SIPL	-	Switching Impulse Protective level
PSCAD	-	Power system computer Aided Design software
IEE	-	The Institution of Electrical Engineers
IEEE	-	Institute of Electrical and Electronic Engineers
S/S	-	Substation
TFR	-	Tower Footing Resistance
TNB	-	Tenaga Nasional Berhad
ZnO	-	Zinc Oxide
HV	-	High Voltage
EHV	-	extra high voltahe

LIST OF SYMBOLS

μF	-	micro-Farad
μH	-	micro-Hendry
μs	-	nicro-second
A	-	Ampere
C	-	Capacitive
Ng	-	Ground Flash Density per Kilometer2 per year
kA	-	kilo-Ampere
kJ	-	kilo-Joule
kV	-	kilo-Volt
L	-	Inductive
MV	-	Mega-Volt
R	-	Resistance
Uc	-	Maximum Continuous Operating Voltage
Ur	-	Rated Surge Arrester Voltage
Km	-	kilometer
V	-	Volt
Z	-	Impedance
Zt	-	Surge Impedance

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Lightning is a natural hazard that is more prevalent in the tropical region. Lightning activity in South East Asia, especially in Malaysia, ranked as one of the highest in the world [19]. Tenaga Nasional Berhad Research (TNBR) Malaysia has recorded as high as 320 kA lightning impulse current in Malaysia using their Lightning Detection Network System (LDNS)[19]. The transmission lines tripping in Malaysia is majorly caused by lightning, which is about 70% [19].

Although the overhead ground wires or shield wires have been located at the transmission line tower to minimize the number of lightning strokes that terminate on the phase conductor, lightning can still strike on the tower or shield wire. This will cause a backflashover. Lightning stroke that terminates, forces currents to flow down the tower and out on the ground wires. Thus, voltages are built up across the line insulation. If these voltages equal or exceed the line critical flashover (CFO) flashover will occur [1]. Study on backflashover is very important to evaluate lightning performance as majority of lightning strokes terminate on shield wire than phase conductor [2].

This project will focuses on the backflashover phenomena at transmission line. Backflashover simulation and analysis are done using PSCAD/EMTDC software. Sample of case, 132 kV MPSS-MCCA transmission line data was taken from Tenaga Nasional Berhad for the purpose of modeling transmission line and backflashover analysis. The simulation results will be obtained by injecting different values of lightning current to every tower of the transmission line. A detailed analysis of the simulated result will be presented throughout.

1.2 Problem Statement

On many transmission lines, lightning is the main cause of unscheduled interruptions especially for lines of 275 kV and below. Figure 1.2 shows the world map of keraunic levels. This map shows that Malaysia lies near the equator where it is characterized as area that experienced high lightning and thunderstorm activities. Data from the Malaysian Meteorological Services Department indicates that Malaysia has an isokeraunic level of more than 200 thunderstorm-days per year [5]. Table 1.1 shows the number of thunderstorm days (T_d) in several part of Malaysia. According to the data, most of the part in Malaysia have T_d more than 100 while in some places such as Ipoh and Subang, its T_d exceed 200. The average, median and maximum peak discharge currents of the first return stroke in Malaysia are 37kA, 32.4kA and 352kA, respectively [5].

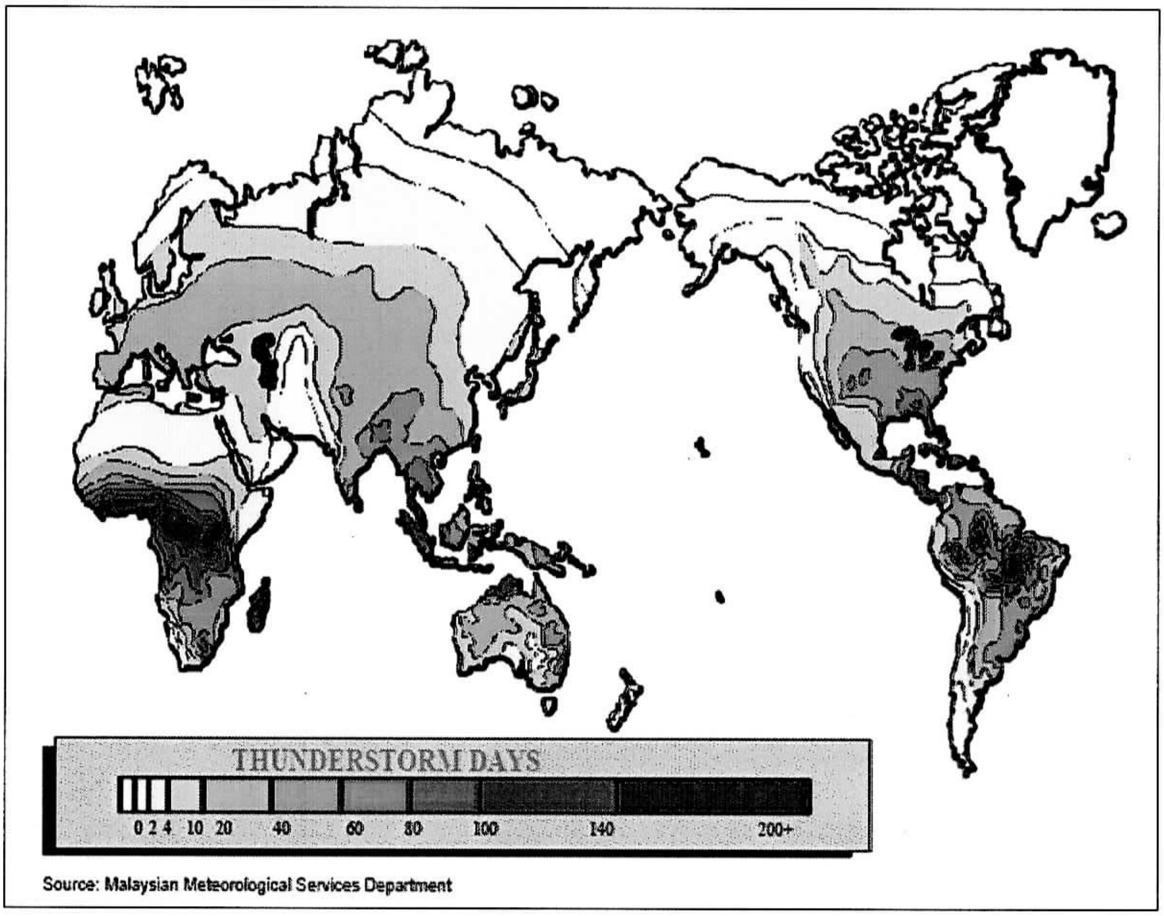

Figure 1.1: World Map of Keraunic Level [5].

Table 1.1: Number of days with thunderstorm in Malaysia [5].

Station	No. of Days with Thunderstorm Year		
	2004	2005	2006
Pulau Langkawi	115	108	128
Kota Bharu	114	126	115
Ipoh	206	180	203
Batu Embun	97	88	99
Subang	211	160	230
Kuantan	129	147	158
Malacca	128	133	157
Mersing	145	162	175
Senai	161	156	171
Kuching	173	181	185
Bintulu	158	114	160
Miri	91	82	88
Kota Kinabalu	108	96	160
Kudat	73	57	93
Tawau	125	128	174
Sandakan	125	118	165

The methods for estimating the lightning performance of transmission lines show several approaches to a real life engineering problem that is ill-defined. Precise constants are rarely known and are often not really constant, input data is difficult to describe mathematically except in idealized ways, and outputs may be despicable only by probabilities or average values. By its nature, lightning is difficult to study and model [15].

Each year, lightning strikes cause millions of dollars in damage for utilities and their customers, including transmission line failure. In an effort to reduce the impact of lightning to the performance of transmission line, accurate and better models to represent transmission line are needed. It is because low accuracy of lightning performance of the transmission line estimation may reduce the transmission line efficiency and reliability.

1.3 Project Objectives

The objectives of the project are:

1. To develop transmission line and lightning model using PSCAD software.
2. To estimate the maximum voltage level at substation entrance, minimum current required to cause of backflashover, and backflashover rate.
3. To estimate probability of the transformer damage at substation.
4. To investigate the influence of line parameters to backflashover rate.

1.4 Scope Of Works

Lightning is one of the main sources of non-programmed interruptions in transmission lines. As known, lightning strokes to transmission lines may cause failures essentially via two phenomena: shielding failure (SF) and backflashover (BF) [1, 2, 3]. Both concur to the formation of the overall number of flashovers on the transmission line.

The main scope of this project is to study the backflashover phenomena on 132kV transmission line and investigate the effects of line parameters to the values of backflashover rate (BFR). The investigated line parameters are:

1. Tower footing resistance and soil resistivity
2. Number of shield wire

These parameters are involved in the modeling of transmission line using PSCAD software. The modeling includes tower, tower footing resistance, insulator coordination and the first return lightning stroke.

1.5 Thesis Outlines

This thesis consists of 6 chapters which are introduction, literature review, methodology, results, analysis and discussion and also the conclusions and further works.

Chapter 1 is the introduction part. This chapter discussed about the introduction of this project problem statement, objectives and scope of project.

Chapter 2 is the literature review. This chapter discussed about the insulation co-ordination, overvoltages, lightning and the problems caused by lightning to power transmission line. Besides that, this chapter also discussed about the component of modeling 132kV transmission line which is modeling of overhead transmission line, lightning stroke, tower, footing resistance, backflashover, and the types of insulator. The best component in modelling of 132kV transmission was selected from previous researcher.

Chapter 3 discusses on the project methodology. It discusses about the software used, the development of overhead transmission line, lightning stroke, tower, footing resistance and insulator coordination gap model in PSCAD. The definitions of cases also have been explained briefly in this chapter include the description of case study 132kV MPPS-MCCA substation.

Chapter 4 discusses all the simulation results. These results are in the value of backflashover current (I_C), maximum voltage at substation (V_{max}), lightning current versus maximum voltage at substation curve (I-V) and also the waveform of the probability of transformer damage. Also, a comparison between the cases is demonstrated in this chapter.

Chapter 5 are present analysis and discussion of the simulation results. The results of all cases will be analyzed and the comparison between the results will be discussed.

Chapter 6 will concludes overall findings of this project. In addition, some suggestions have been made based on the project findings. Hopefully with this suggestion, better result and outcomes can be obtained in the futures.

CHAPTER 2

LITERATURE REVIEW

2.1 Insulation Coordination

Insulation coordination is the process to determine the proper insulation level of several components in the transmission line as well as their placement on the system where it would result in the least damage [1]. It is the selection of an insulation structure that will withstand voltage stresses to which the system or equipment will be subjected to together with the proper surge arrester to reduce frequency of supply interruptions and component failure. The process is determined from the known characteristics of voltage surges and the characteristics of surge arresters

According to IEC Publication 71 (1993), insulation coordination can be define as the selection of the dielectric strength of equipment in relation to the voltages which can appear on the system for which the equipment is intended and taking into account the service environment and characteristics of the available protective devices. While, IEEE standard (1996) define insulation coordination as the selection of insulation strength consistent with expected overvoltages to obtain an acceptable risk of failure. Besides that, according to A.R.Hileman define insulation coordination as the protection of electrical systems and apparatus from harmful overvoltages by the correlation of the characteristics of protective devices and the equipment being protected [1].

Usually, insulation coordination is separated into two major parts [1]:

1. Line insulation coordination which can further separated into transmission and distribution lines.
2. Station insulation coordination, which includes generation, transmission and distribution substations.