“I hereby declare that I have read through this report entitle “Proposed Metal-Oxide Surge Arrester Model to Improve Lightning Protection” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)”

Signature : ....

Supervisor’s Name : En. Zikri Abadi Bin Baharuddin..

Date : ....June 2012…….....................

PROPOSED A METAL-OXIDE SURGE ARRESTER MODEL TO IMPROVE LIGHTNING PROTECTION

LOW SIEW YI

This report is submitted in partial fulfillment of requirement for the degree of bachelor in electrical engineering (Industry Power)

Faculty of Electrical Engineering

UNIVERSITY TECHNICAL MALAYSIA MELAKA

2012

2012

I declare that this report entitle "Proposed Metal-Oxide Surge Arrester Model to Improve Lightning Protection" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : ....LOW SIEW YI.................

Date : ....June 2012.........................

To my beloved family

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ABSTRACT

Lightning strike is the major factor that leads to overvoltage and equipment damage in electrical power system. The metal-oxide surge arrester is one of the protective device that can be used to reduce lightning effect. This project mainly investigates the effectiveness of the developed surge arrester to improve the lightning protection quality and reduce costs of surge arrester. The crucial part of this research is calculation and adjustment of the surge arrester model parameter. In this project, lightning stroke and surge arrester are modeled. In general, the proposed metal oxide surge arrester was constructed base on IEEE Working Group (WG) 3.4.11 mode using Power System Computer Aided Design (PSCAD). In addition, the Pinceti and IEEE surge arrester model was also introduced for comparative purposes. It is found that the proposed model is the best surge arrester model when injected by 5kA and 10kA current impulse 8/20µs since it have similar value of residual voltage with manufacturer tested results. On the otherhand, the IEEE surge arrester model was found to be the most suitable model when inject 20kA and 40kA current impulse. The result from this project can be as a guideline to the surge arrester designers or electrical power engineer for improving the surge arrester performance as well as the scheme protection system.

ABSTRAK

Kilat merupakan faktor utama yang menyebabkan voltan lampau dan kegagalan pada electrik sistem. Konduktor kilat adalah alat perlindungan yang digunakan untuk menentang kilat. Model. Kajian ini akan menyiasat keberkesanan daripada konduktor kilat yang baru dibangun untuk meningkatkan kualiti perlindungan kilat dan juga mengurangkan harganya. Bahagian yang paling penting dalam kajian ini adalah pengiraan “parameter” semasa membangunkan konduktor kilat. Projek ini mengetengahkan, model kilat dan model konduktor kilat.. Kajian ini akan membangunkan suatu konduktor kilat yang berasal dari IEEE Kumpulan Kerja (WG) 3.4.11 Dalam kajian ini, semua model akan dibentuk dengan menggunakan sejenis alat simulasi sistem kuasa simulasi iaitu perisian Power System Computer Aided Design (PSCAD) dan keputusan akan dibincangkan berdasarkan kajian literature, berbanding antara model dan analisis hasil. Selain daripada itu, model Pinceti dan model IEEE akan dibangunkan untuk berbandingan tujuan. Ia didapati bahawa model yang dicadangkan adalah model yang terbaik apabila menyuntik 5kA dan 10kA arus impuls, ini adalak kerana ia ada nilai voltan lebih yang paling dekat dengan data pengilang.Selain daripada ini, IEEE model adalah model yang paling sesuai untuk 20kA and 40kA. Hasil daripada projek ini boleh menjadi garis panduan kepada pereka konduktor kilat atau lain-lain untuk meningkatkan prestasi konduktor kilat

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LIST OF ABBREVIATIONS

AC	- Alternating Current
DC	- Direct current
FYP	- Final Year Project
PSCAD	- Power system computer Aided Design software
IEE	- The Institution of Electrical Engineers
IEEE	- Institute of Electrical and Electronic Engineers
IEC	- International Electrotechnical Commission
MCOV	- Maximum continues operating voltage
MOV	- Metal Oxide Surge Arresters
SiC	- Silicon Carbide

LIST OF SYMBOLS

μF	- micro-Farad
μH	- micro-Hendry
μs	- micro-second
A	- Ampere
Ng	- Ground Flash Density per Kilometer2 per year
kA	- kilo-Ampere
kV	- kilo-Volt
L	- Inductive
R	- Resistance
Km	- kilometer
pF	- piko-Farad
V	- Volt
Z	- Impedance

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

According to Malaysian Meteorological Services Department, most state of Malaysia has a number of days with thunderstorm, T_d more than 100[1]. The lightning may cause serious consequence for the operating, maintaining and designing of the electrical power system as well as protective device like surge arrester. For example, lightning can cause backflashover and induced overvoltages generate surge voltage that can cause damage to substation or power plant equipment as shown in Figure 1.1.

Figure 1.1 Damage to the transformer at TNB substation

Therefore, it is very important to investigate and propose some idea for improve the lightning protection scheme in electrical power system. This can be done by proposed a new surge arrester model, simulate using PSCAD. An accurate surge arrester model will increase the lightning protective level of the electric power system.

1.2 Objective:

Objective of this project are as follows:-

i. To design and develop a surge arrester model using PSCAD software.
ii. To develop IEEE and Pinceti metal-oxide surge arrester model using PSCAD software.
iii. To develop the lightning stroke using PSCAD software.
iv. To evaluate the effectiveness of the metal-oxide surge arrester model by comparing with others two common surge arrester model.

1.3 Scope of Work:

Scopes of this project are as follow:-

i. This project only concern on surge arrester lightning protection performance.
ii. The surge arrester model is design based on 132kV electrical power system.
iii. The lightning current waveshape of 8/20µs with peak amplitude of 5kA, 10kA, 20kA and 40kA were used to represent lightning strike.

1.4 Thesis Outlines

This report is divided into six chapters. Basically, some theory and literature review, introduction, methodology, simulation result, comparison of result, analysis and discussion and conclusion were included in these six chapter.

Chapter 1 includes the project objective, problem statement, scope of work and thesis outlines. Continue by Chapter 2 presents the literature review on this project such as system overvoltage, phenomena of lightning, formation of lightning, fundamental of surge arrester, type of surge arrester and surge arrester parameter.

In chapter 3 presents the process of the project in order to achieve the objective of the project. Other than this, also include the method to developed lightning stroke and surge arrester model using PSCAD. The method will be presented in flow chart.

Chapter 4 includes the result and data. In this chapter, 8/20µs lightning current waveform with peak amplitude of 5kA, 10kA, 20kA and 40kA are injected to each surge arrester model. All the data are recorded and compare to the manufacturer data to investigate the effectiveness of the surge arrester model. Chapter 5 discusses all the data we get by comparing with manufacturer data sheet.

Lastly, Chapter 6 concluded all the works and studies that had been presented in the previous five chapters. Besides, some recommendations as well as the contributions to the project will be mentioned.

CHAPTER 2

LITERATURE REVIEW

2.1 System Overvoltage

According to [2], the characteristic of overvoltage is defined as the voltage appears during abnormal operating conditions or during transitions between steady states. Furthermore, the overvoltage can have values much higher than the system operating voltage. Overvoltage also forms a threat to the integrity of the system and the safety of personnel.

Generally, there are 3 types of overvoltage according to IEC60071-1(2004), which are lightning overvoltage, switching overvoltage, temporary overvoltage. Figure 2.1 shows graph per-unit ($p.u$) voltage versus duration of overvoltage occurs [3].

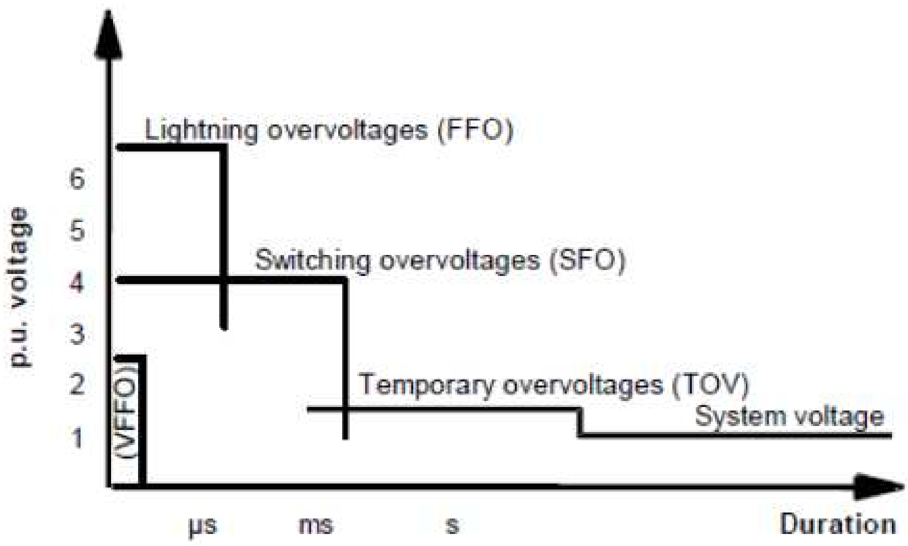

Figure 2.1 Types of overvoltage [3]

M.S. Naidu and V. Kamaraju (2006) stated that the making and breaking of electrical circuit in power system can cause abnormal overvoltage that may go as high as six times the normal power frequency voltage [4].

2.2 Lightning

Lightning is an atmospheric electrostatic discharge (spark) accompanied by thunder, which typically occurs during thunderstorms, and sometimes during volcanic eruptions or dust storms which measure in kilometer[5].

IEEE Std. 1410-2004 (2010) state that, the amount of lightning that can occur in a country or continent is based upon the Keraunic level in this case is defined as the number of thunderstorm days time [6]. Figure 2.2 shows the number of days with thunderstorm in Malaysia.

Figure 2.2: Number of days with thunderstorm, T_d in Malaysia[7]

According to Figure 2.2, most of the state in Malaysia have more than 100 number of days with thunderstorm, T_d. Analysis from Malaysian Meteorological Services Department indicates that the highest annual no. of days of lightning and thunder storm at Subang is 309 and 211[1].

Basically, there are four types of lightning, which are cloud-to-ground downward positive, cloud-to-ground downward negative, ground-to-cloud upward positive and ground-to-cloud upward negative as shown in Figure 2.3 to 2.6 respectively [8].

Figure 2.3: Cloud-to-ground downward negative lightning[8]

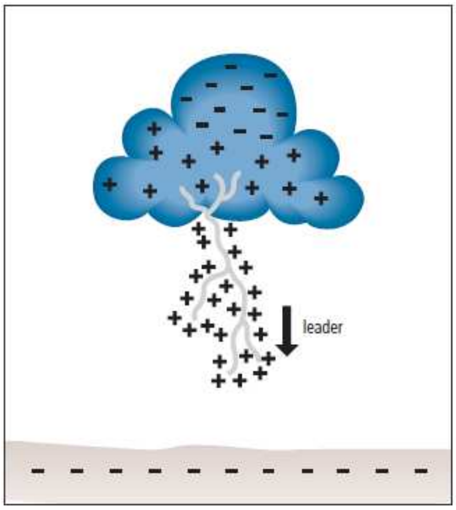

Figure 2.4: Cloud-to-ground downward positive lightning[8]

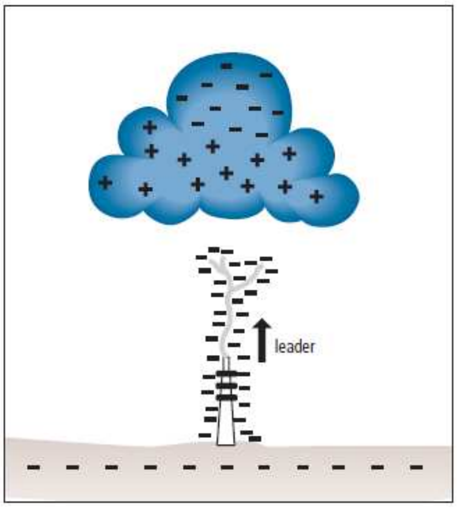

Figure 2.5: Ground-to-cloud upward negative lightning [8]

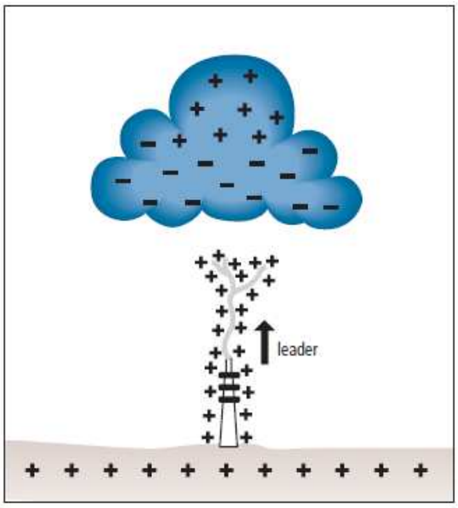

Figure 2.6: Ground-to-cloud lightning upward positive [8]

However, only cloud-to-ground lightning has been studied widely due to human safety. According to Martin A. Uman and Rocov (2001), about 90% of cloud-to-ground lightning is downward moving negative charged leader while only 10% of the cloud-to-ground lightning is downward moving positive leader, where downward negative charged leader is a leader filled with negative cloud charged pushes its away from the cloud to earth. After leader, there is a current travels from ground to cloud, called return stroke.