PERFORMANCE ANALYSIS OF STACKED CAPACITIVE AND MULTI-LOOP ANTENNAS FOR LIGHTNING REMOTE SENSING APPLICATION

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DECLARATION

I declare that this report entitled "Performance Analysis of Stacked Capacitive and Multi-Loop Antennas for Lightning Remote Sensing Application" is the result of my own work except for quotes as cited in the references.

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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 Bachelor of Electronic Engineering with Honours.

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Supervisor Name : DR MOHD RIDUAN AHMAD

Date : 28/5/2018

DEDICATION

The completion of this project is not only by hard work but also guidance and support from so many peoples. Their contribution sincerely appreciated. I dedicated this works to my parents and family. “A truly great mentor hard to find, difficult to part with, impossible to forget”, this project is dedicated to the man, Dr. Mohd Riduan Ahmad who taught me important lessons, and always be continual source of knowledge and inspiration..

ABSTRACT

Antennas are the important elements in the lightning detection system. To improve performance of the lightning detection system, it is so necessary to improve the efficiency of the antennas. There are two types of antennas used in the system which are capacitive antenna for electric field sensing and loop antenna for magnetic field sensing. Both of these antennas are big in size and causing inconvenient during set up. Thus, small and portable antennas are designed. It is so important to remain or improve the sensitivity of the antennas even though it is small in size. Stacking method is used in capacitive antenna by increase copper plate layer in between the parallel plate antenna while sensitivity of loop antennas is increased by increasing the number of turns of the antennas. After prototype the multi-stacked capacitive antenna and multi-loop antennas, performance analysis is carried out. Performances of the antennas are compared using CST simulation and hardware set up. Multi-stacked capacitive antenna is compared with the single plate antenna and found that the performance of the antenna increases as the stacked number increases. On the other hand, multi-loop antennas are also set up for real time lightning detection. Multi-loop antennas are still able to detect the direction of the magnetic field emitted by the lightning events even though the size becomes small.

ABSTRAK

Antena merupakan elemen yang penting dalam sistem pengesanan kilat. Terdapat dua jenis antena dalam sistem pengesanan kilat iaitu antena kapasitif dan antena gelung. Antena kapasitif digunakan sebagai penderia untuk medan elektrik manakala antena gelung berperanan sebagai penderia medan magnet. Oleh kerana kedua-dua antena ini bersaiz besar maka selalu menjadi masalah untuk membawa mahupun memasang antena tersebut. Oleh kerana itu, kecekapan antena harus ditingkatkan dan ditambahbaik supaya masalah saiz antena boleh diselesaikan. Pertama sekali, lapisan tembaga dalam antena kapasitif ditambah supaya dapat meningkatkan nilai kapasitans di antara lapisan atas dan bawah sekali. Peningkatan nilai kapasitans boleh meningkatkan medan elektrik. Di sebaliknya, antena gelung perlu menambah nombor kiraan gelung supaya meningkatkan kekuatan medan magnet yang diterima. Selepas membuat prototaip kedua-dua antena, analisa telah dibuat melalui simulator CST dan juga melalui pengukuran sebenar di lapangan. Sebagai kesimpulan, antena kapasitans yang berlapisan adalah berfungsi lagi baik berbanding yang biasa manakala prestasi antena gelung juga ditambahbaik dengan meningkatkan nombor kiraan gelung.

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LIST OF SYMBOLS AND ABBREVIATIONS

E-Field	:	Electric field
B-field	:	Magnetic field
CST	:	Computer Simulation Technology
Hz	:	Hertz
EMF	:	Electromagnetic Field

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CHAPTER 1

INTRODUCTION

1.1 Background

Lightning is a normal phenomenon happen around the environment and known by every people on earth. Actually, lightning is an electrostatic discharge inside the thunderstorm. Due to the tripole structure of the thundercloud, lightning is either occurring between cloud and ground, between clouds or in different regions of cloud [1]. Electromagnetic radiation from the electrical breakdown can covered large frequency spectrum from a few Hz up to GHz. The effects of the lightning strike can be very big and able to kill a man in a few second.

It is so much important to have own design lightning detector instead of purchasing high cost system from the oversea. We are able to detect the thunderstorm and lightning using own developed system which give convenient to all the Malaysian to avoid fatalities caused by lightning and prevent the server's data losses as well as malfunctioning of control automation machinery in factories.

Lightning detection system involve a few parts which are antennas, buffer circuits, picoscope and display screen. To develop high performance lightning detection system, antennas play very important roles. Sensitivity of antennas should be high enough to ensure the accuracy of collected data. There are single plate capacitive antenna and single loop antennas use in this system. Capacitive antenna is use for electric field measurement while loop antenna for magnetic field detection.

For this project, a better and high accuracy lightning detection system is planned to be designed by increasing the sensitivity of the antennas. This high sensitivity system can be useful as the alarming system for lightning events and a precaution on severe destruction of field-sensitive appliances. Besides, high accuracy of collected data will be helpful for future researches and lightning knowledge development.

1.2 Problem Statement

Current available lightning detection system is using single plate capacitive and single loop antennas to detect the electromagnetic field emission of lightning events. As reported, single plate capacitive and single loop antennas have lower sensitivity in Computer Simulation Technology (CST) software and the radiation pattern of the induced electric field is not satisfied. This dedicate that the performance of antennas may having low sensitivity and can be improved.

Besides, the size of single plate capacitive and single loop antennas in lightning detection system is big in sizes where dimension of capacitive antenna is about A4 size (200cm x 300cm x 2cm) and loop antenna with dimension (75cm x 75cm x 75cm). The big sized antennas may cause some difficulties in technical issues and easily affected by the surrounding factors. Strong wind and rain may influence the orientation angle of the antenna since the system is difficult to shield.

Therefore, it is worth to look into the possibility of making small and portable antennas with high sensitivity.

1.3 Objective / Aim

Aim:

a) Investigation on the relationship between stacked capacitive antennas and resulted electric field strength compare to single plate antenna
b) Investigation on the relationship between multi-loop antennas and induced electric field strength compare to single loop antenna.

Objective:

a) To increase the sensitivity of both capacitive and loop antennas
b) To prototype portable capacitive and loop antennas
c) To analyse and evaluate performance of new antennas using both CST software and hardware setup

1.4 Scope

The scope of research consists of 2 parts (A and B part) which are electric field sensor (capacitive antenna) and magnetic field sensor (loop antenna). In order to construct and build a practical and user-friendly system, this project deal with CST