UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANTENNA DESIGN FOR DETECTION OF ANGULAR MOMENTUM SIGNAL FROM LIGHTNING

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical and Electronic Engineering Technology (Telecommunication) with Honours

by

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DECLARATION

I hereby, declared this report entitled “Antenna Design for Detection of Angular Momentum Signal from Lightning” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Electric and Electronic Engineering Technology of UTeM as a partial fulfillment of the requirements for the Bachelor Degree of Electric and Electronic Engineering Technology (Telecommunication) with Honours.

The member of the supervisory is as follow:

……

Sir Ahmad Sayuthi bin Mohamad Shokri

(Project Supervisor)

ABSTRACT

Lightning flash is an electrical discharge in air which is in scientific term, it is called as dielectric breakdown. It emits the electromagnetic fields across wide spectra which is from few Hertz (Hz) up to Mega Hertz (MHz). Lightning has many types of flash such as cloud-to-ground (CG), Compact Intracloud Discharge (CID), Intra-cloud (IC), Narrow Bipolar Event (NBE), and Preliminary Breakdown Pulse (PBP). There are two categories of antenna in lightning detection application which are fast field detection and slow field detection. Circular Patch Antenna is developed to detects and radiates orbital angular momentum signal. It is widely used in Wi-Fi communication spectrum which is 2.45GHz. However, this antenna has been modified to work in low frequency spectrum for lightning application. The antenna is capable to work in range few hertz to 3.535MHz after the modification been made. The result of circular patch antenna in this project is compare with the existing antenna in lightning detection which is air-gap antenna. The comparison for both antenna are using temporal analysis. Temporal analysis helps to determine the difference of amplitude, ratio, and average for these two antennas. As a results, circular patch antenna operates in peak performance at 1KHz in lightning application.

ABSTRAK

Petir kilat adalah pelepasan elektrik di udara yang dalam istilah saintifik, ia dipanggil pecahan dielektrik. Ia memancarkan medan elektromagnet di seluruh spektrum yang luas dari beberapa “Hertz” (Hz) hingga “Mega Hertz” (MHz). Petir mempunyai banyak jenis kilat seperti *cloud-to-ground* (CG), *Compact Intracloud Discharge* (CID), *Intra-cloud* (IC), *Narrow Bipolar Event* (NBE), dan *Preliminary Breakdown Pulse* (PBP). Terdapat dua kategori antena dalam aplikasi pengesanan kilat yang pengesanan lapangan pantas dan pengesanan lapangan perlahan. Antena *Circular Patch* dibangunkan untuk mengesan dan memancarkan isyarat momentum sudut orbit. Ia digunakan secara meluas dalam spektrum komunikasi Wi-Fi iaitu 2.45GHz. Walau bagaimanapun, antena ini telah diubah suai untuk bekerja dalam spektrum frekuensi rendah untuk aplikasi petir. Antena mampu bekerja dalam jarak beberapa “Hertz” hingga 3.535MHz selepas pengubahsuaian dibuat. Hasil antena *Circular Patch* dalam projek ini dibandingkan dengan antena sedia ada dalam pengesanan kilat yang merupakan antena jurang udara. Perbandingan untuk kedua-dua antena menggunakan analisis temporal. Analisis temporal membantu menentukan perbezaan amplitud, nisbah, dan purata bagi kedua-dua antena ini. Sebagai hasilnya, antena patch bulat beroperasi pada tahap maksima pada 1KHz dalam aplikasi petir.

DEDICATION

I dedicate this thesis to my beloved families, supervisor and co-supervisor, seniors, and those who involved in a process completing this thesis.

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Alhamdulillah, all praises to Allah, the Lord of the Universe. Blessings and greeting to prophet Muhammad S.A.W, his family and companions.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CG	-	Cloud to Ground
CID	-	Compact Intracloud Discharge
DC	-	Direct Current
F	-	Farenheit
G	-	Giga
Gs/s	-	Giga sample per second
Hz	-	Hertz
IC	-	Intra-cloud
K	-	Kelvin
KHz	-	Kilo Hertz
M	-	Mega
mm	-	milimeter
ms	-	milisecond
NBE	-	Narrow Bipolar Event
PBP	-	Preliminary Breakdown Pulse
s	-	Second
V	-	Voltage
W	-	Watt

° C	-	Celcius
Ω	-	Ohm
µ	-	micro
%	-	percentage

CHAPTER 1
INTRODUCTION

1.0 Introduction

Angular momentum signal is a signal that resulted in three dimension waveform. Angular momentum is a form of the quantity of rotation of a body, which is the product of its moment of inertia and its angular velocity. In general, there are only two types of signal produced in communication field which are transverse direction and angular momentum. Theoretically, transverse signal is a signal that has particular electromagnetic field pattern of the radiation in the plane perpendicular to the radiation's propagation direction. Angular momentum signal is produced and to spread many more data at all directions rather than transverse signal. The antenna design for detection of angular momentum signal from lightning is purposely made to collect lightning signal in more details. This chapter will discuss on the background, objectives, problem statement, and scope of this project.

1.1 Background

The purpose of this project is to design an antenna for detection of angular momentum signal from lightning. The idea of designing and developing this antenna is to evaluate the performance of lightning signal in further details. The current antenna used for lightning detection is resulted in transverse direction only. The graphs as shown below are some of the

lightning signal displayed in transverse waveform type. Based on the graphs adapted by Rakov in 1999, these are the illustration of electric field pulse waveforms characteristic of the initial breakdown in negative ground flashes (CGs), the initial breakdown in cloud flashes (ICs), and compact intracloud discharges (CIDs). Positive electric field which is atmospheric electricity sign convention upwardly deflects.

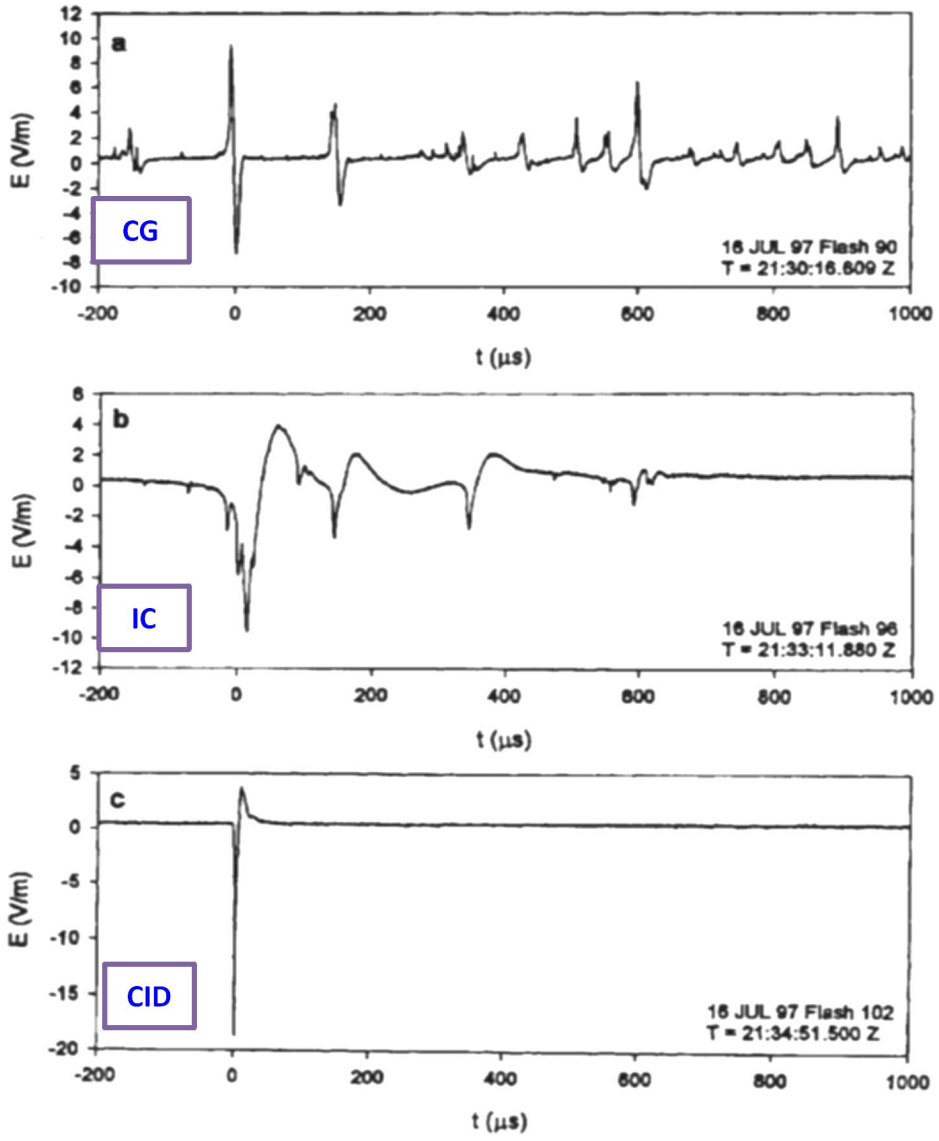

Figure 1.1: Electric field pulse characteristic of the CGs.

In material science, angular momentum is a rare moment of momentum or rotational momentum is the rotational equivalent of linear momentum. It is an essential quantity in physics because it is a conserved quantity in which the total angular momentum of a system remains constant unless performed on by an external torque. In lightning applications, angular momentum is capable to measure rotating force in thunderstorm so that we know the actual power produced by each lightning strike.

1.2 Problem Statement

The current antenna is using transverse detection from lightning which it gives not so many data to the researchers or so called as 'storm chasers'. However, can angular momentum be measured? Can we use the existing antenna to detect angular momentum?. These are the common question received from people especially from the researchers and forecast engineers. This is because nobody knows the antenna capabilities in detecting signal but the truth is angular momentum signal does exist.

1.3 Objectives

At the end of the thesis, we are able to:

I. To design an antenna that capable to detect angular momentum in CST simulation software at low frequency (1KHz to 1MHz).
II. To evaluate the performance of designed antenna in terms of gain, efficiency, and radiation pattern.
III. To develop an antenna that detect lightning from all direction (0° to 360°) at 1KHz.

1.4 Scopes

The scope of this project is that the designed antenna is only capable to detect angular momentum signal at low frequency range from 1KHz until 1MHz. Furthermore, this antenna is purposely made in receiving signal not even transmitting signal. This antenna is only receive lightning signal up to 300km radius.

1.5 Thesis Outline

This report is split into three chapters to provide a strong understanding of the entire project. It wills also shows the rational steps involved in understanding and gaining an appreciation of the methodology used to build the model of the project.

Chapter 1:

The first chapter introduces a brief idea of the project. Overview of the project will be cover. This chapter will be explaining the synopsis of the project, the project objective, scopes of the project, the problem statement, and outcome of the project.

Chapter 2:

This chapter is the medium to gain information so that it can be develop the project. The research information's will described by an articles, journal, books and some related interview.

Chapter 3:

In this chapter it will explain all the methodology and a project implementation process so the goal can be achieved. The software technical and hardware details are also explained in this chapter.

Chapter 4:

This chapter will show and explain all the results from simulation software and hardware analysis. Besides, the discussions been discussed in this chapter especially about the comparison of the existing antenna and circular patch antenna.

Chapter 5:

The last chapter concludes an overall idea of the project and the overall performance of the circular patch antenna. Besides, this chapter also determined either the objectives of this project have achieved. Lastly, the recommendation for future works of this project are discuss.

CHAPTER 2
LITERATURE REVIEW

2.0 Overview

Lightning emanates an electromagnetic heartbeat that is transmitted range ranges from only a couple of hertz up to many megahertz. Because of the sub-millisecond to millisecond time scales and a few kilometer spatial scales related with the lightning current, a large portion of the vitality in the emanated range is restrained in the Extremely Low Frequency (ELF 3-3000 Hz) and Very Low Frequency (VLF 3-30 KHz) bands. In 2013, V.A. Rakov state that lightning can be characterized as a transient, high-flow which commonly in kilo amperes electric release in air whose length is estimated in kilometers. With respect to any release in air, lightning channel is made out of ionized gas that is, of plasma, whose top temperature is ordinarily 30,000 K approximately multiple times higher than the temperature of the outside of the Sun. Lightning was available on Earth some time before human life developed and it might even have assumed a significant job in the advancement of life on our planet.

2.1 Analysis and Investigation on Lightning Electromagnetic Coupling Effects of a Dipole Antenna

K. Liu, X. Mou, S. Li, and Y. Du have done a research on analyzing and investigating for lightning electromagnetic coupling effects of a dipole antenna in year 2017. The objective of this research is to explore about the coupling impact of a antenna close to the lightning channel when the remote base station lightning bar is assaulted by lightning. The reproduction forms of lightning channel-correspondence tower and dipole antenna taking a shot at the communication recurrence of 900 MHz are built in this paper dependent on the simulation in CST Studio Suite and FEKO software.

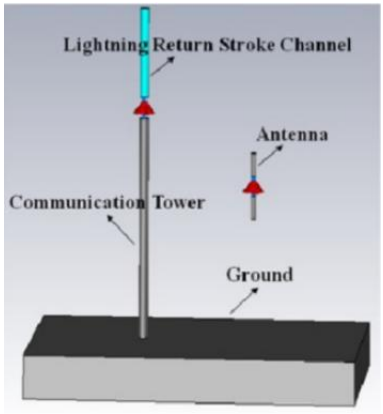

Figure 2.1(a): Antenna model

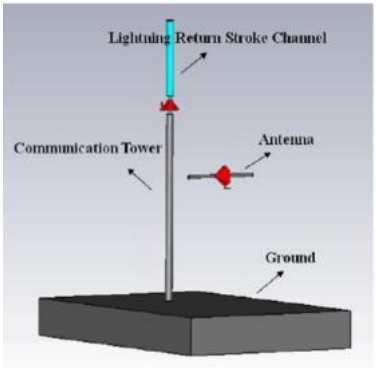

Figure 2.1(b): Antenna model