UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MEASUREMENT OF MAGNETIC FIELD GENERATED BY LIGHTNING FOR DETERMINATION OF LIGHTNING STRIKE DIRECTION

This report submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours

by

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TAJUK: **Measurement of magnetic field generated by lightning for determination of lightning strike direction**

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I hereby, declared this report entitled "Measurement of magnetic field generated by lightning for determination lightning strike direction" 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 Engineering Technology of UTeM as a partial fulfillment with the requirements for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

…….

(DR. ZIKRI ABADI BIN BAHARUDIN)

ABSTRACT

This project was to develop a lightning detection system where it will be focused on measurement of magnetic field generated by lightning for determination of lightning strike direction. There are lots of detection system to determine the lightning strike such as the Lightning Positioning and Tracking System (LPATS) and Lightning Location and Protection (LLP). Magnetic direction finding is one of them. The measurement of the magnetic field produced by lightning detected using an antenna that act as a sensor. The loop antenna is developed by using PVC and coaxial cable with 50 ohm impedance is placed inside. Furthermore, the antenna is measured on the North and South component only. Output of the antenna is connected to the active integrator circuit by using AD8067 for the purpose of integrates the voltage output from the loop. PCB design of the circuit is used OrCAD software. From the circuit the measurement of the dB/dt observed the waveform on the Teledyne LeCroy HDO4024 digital storage oscilloscope (DSO). The lightning strike activity is monitored time by time. Throughout this project, the several parameter from magnetic field of the output loop antenna can determine the direction of lightning strike with some mathematic calculations and equations. The distance had been determined from the range of 0.5 km to 40 km and the lightning strike direction is defined on the East due to the cloud propagation. In conclusion, the objectives are successfully achieved and further research need to be done to increase the result accuracy of this project.

keyword: **Lightning Strike Direction, Measurement of magnetic Field, Loop Antenna, OrCAD, Digital Storage Oscilloscope.**

ABSTRAK

Projek ini adalah untuk membina sistem pengesanan kilat berdasarkan ukuran medan magnetik yang dihasilkan oleh kilat untuk mengkaji arah panahan kilat itu berlaku. Terdapat banyak sistem pengesanan menentukan panahan petir seperti Lightning Positioning and Tracking System (LPATS) and Lightning Location and Protection (LLP). Penemuan arah magnetik ialah salah satu teknik sistem pengesanan yang lain. Ukuran medan magnetik dihasilkan oleh kilat dikesan dengan menggunakan antenna sebagai sensor. Antena gelung dibangunkan dengan menggunakan PVC dan kabel sepaksi 50 ohm yang diletakkan di dalamnya. Selain itu, gegelung antenna dibangunkan mengikut arah Utara dan Selatan sahaja. Output antena akan disambungkan kepada litar pengamiran aktif menggunakan AD8067 dengan tujuan untuk mengintegrasikan output voltan dari antena gelung tersebut. Reka bentuk litar PCB akan menggunakan perisian OrCAD. Dari litar pengamiran aktif tersebut ukuran dB/dt akan diperhatikan dalam bentuk gelombang di osiloskop storan digit (DSO) Teledyne LeCroy HDO4024. Kegiatan panahan petir akan dipantau dari masa ke masa. Keseluruhan projek ini, pengesanan voltan medan magnetik daripada output antenna gelung dapat menentukan arah panahan petir dengan menggunakan sedikit pengiraan matematikal. Panahan kilat dapat dikesan dalam lingkungan 0.5 km hingga 40 km dan arah yang dikenalapasti adalah daripada arah Timur berdasarkan pergerakan awan. Kesimpulannya, keseluruhan objektif berjaya dicapai tetapi penambahbaikan perlu dilakukan untuk meningkatkan tahap ketepatan data yang akan diperolehi pada masa hadapan.

Kata Kunci : **Arah panahan Kilat, Ukuran Medan Elektromagnet, Antena Gelung, OrCad, Osiloskop Storan Digit.**

DEDICATIONS

Specially dedicated to my beloved family

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My deepest gratitude also extends to Mr. Asri bin Din, my co-supervisor for his kind guidance and encouragement throughout this project development.

I would like to thank my parents and family for giving me full support, understanding and patience. Without their support, I would not have been able to finish my research project.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	=	Alternating Current
BDP	=	Bachelor Degree Project
BNC	=	Bayonet Neill-Concelman
CG	=	Cloud-to-Ground
CC	=	Cloud-to-Cloud
DC	=	Direct Current
DSO	=	Digital Storage Oscilloscope
MF	=	Magnetic Field
EMTR	=	Electromagnetic Time Reversal
Hz	=	Hertz
IC	=	Intracloud
KM	=	Kilo Meter
MHz	=	Mega Hertz
PCB	=	Printed Circuit Board
PVC	=	Polyvinyl chloride
UTM	=	Universal Transverse Mercator Projection
$\vec{B}$	=	Magnetic flux density

CHAPTER 1
INTRODUCTION

1.0 Introduction

This section will be reviewed about the whole idea of this project. The problem statement, objective and the purpose on the development of this project will be elaborated. Overall of this project is to determine the lightning strike direction from generated electromagnetic field.

1.1 Background

Lightning is the most interesting phenomena that occur in the universe. The discoverable of this nature is remain mystery and never settle. Positive and negative charges that contain in the interior of the storm cloud polarized cause lightning strike. According to (Krehbiel, P.R, 1986) conducting air around the storm transfer to the earth surface will form the lightning discharge. This project is about implementation of lightning detection system by measuring the electromagnetic field to determine lightning strike direction.

There are three primary types of lightning which is intracloud (IC), cloud-to-cloud (CC), cloud-to-ground (CG). Discharge from the lightning produce electromagnetic field in a wide frequency range from Hz to MHz. The frequency of waveform will be used to measure the direction of lightning strike.

In this thesis, lightning detection will be consist of antenna system as magnetic field sensor. Besides that, the electric field antenna also will be measured on the same time by other researcher to determine the correlation. Furthermore, the other mechanism were gain from some calculation from previous researchers and data experiment.

1.2 **Problem Statement**

The discharge or lightning produce huge electrical energy and measured from thousand to 200,000 amps. The effect of the lightning strike can cause damage, destruction and dangerous for the human being in this universe even though the discharge is in fast speed. Besides that, magnetic field generated by natural phenomena and man-made is considered as radiation field that probably can harm or affect the electrical and electronic system. However the level of effect due those two unwanted signal still unknown. Therefore the cause of unwanted signal by natural signal by natural phenomena and man-made to be investigate thoroughly. From this problem proposed a detection systems will be developed.

1.3 **Project Objective**

There are two objective on this project which are :

a) To develop hardware for detection of magnetic field caused by lightning strike.

b) To determine lightning strike direction from the magnetic field generated.

b) To determine the correlation between the highest peak of the magnetic field signal and distance

1.4 **Project Scope**

This project scope firstly will be focused on the characteristic of lightning which is negative cloud to ground. Because, it was recorded that this type of lightning happened most in Malaysia.

From this development and construction hardware for detection of electromagnetic field caused by lightning strike will used the antenna systems. Additional circuit to control and complete the design of this systems will be done by using software OrCAD.

Moreover, there will be some method will be used on the determination of lightning strike direction. The magnetic field and electric field will be sampled continuously on digital storage oscilloscope (DSO). Electric field system that will done by other researcher will measured at the same time in order to determine the distance which the direction of lightning strike is depend on it.

Besides that, the determination direction of the lightning event experiment will be implemented on electromagnetic antenna systems to measure the field. The location scope of this systems will be installed at one location which is Paya Rumput, Melaka.

1.5 Significant of The Project

The significance causes on the development of this project, as follows:

a) Introducing lightning detection system to measure magnetic field.

b) To create effective awareness on the protection against lightning.

1.6 Organization

This thesis is divided into 5 chapters. Chapter 1 focused on the background of this project. Chapter 2 would emphasize about lightning phenomena, and how to determine the lightning strike direction and literature review on previous thesis. Chapter 3, would explain about the methodology of the project, procedure on development of the project consist of software, hardware and tool that will be used. Chapter 4 will clarify all the data measured and analyze the waveform consecutively to determine the lightning strike direction. Finally, chapter 5 will concluded overall process of this project whether successful of not. In addition, this last chapter will give a suggestion or recommendation for the future work of this project.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This segment is the literature review of this project that involves material from many sources. The lightning phenomena occur with the discharge particle, electromagnetic field and the determination of lightning direction is reviewed in this segment.

2.1 Lightning Phenomena

Lightning is the amazing power of nature from the sudden of electrical discharge from the storm cloud that have intrigued scientist and engineer for decades. High-current that produce by lightning about amperes to tens kilo amperes can be harmful to mankind and damage electronic and electrical systems. The brightness and intensity of lightning flash against cloud create otherworldly nature phenomenon.

2.2 Lightning Discharge

The discharge of the electricity around the cloud storm in the atmospheric caused a thunderstorm. The basic principle on how the lightning occur is from electron and proton which is negative and positive charges. Cloud are made of millions of tiny particles and ice crystals. The interior of the storm cloud contain dipolar charges that separate between negative and positive charge. Positive charges are distribute to the upper of the cloud while the electrons at the bottom of the cloud.

Conducting clear air at the atmospheric ionized and torn apart between the positive and negative charge will produce electric field that is negative at the bottom and positive at the top. As the collision continues, the conducting path appears between the cloud and the earth with the strong electric field. Thus, the cloud electricity will discharge to the earth's surface and whatever charge accelerates it will emits light and this is called lightning. The thunderstorm charges illustrated in Figure 2.1 below.

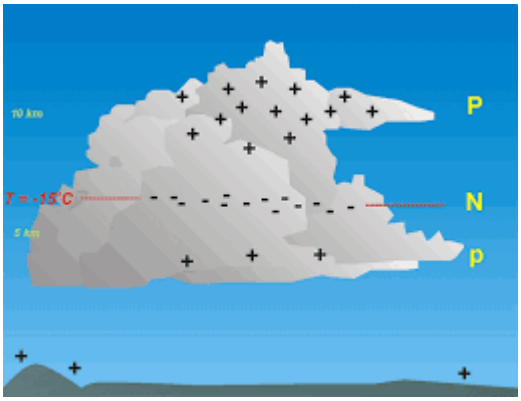

Figure 2.1: Thundercloud charges, P- positive charge uppermost region, N-negative charge and p-positive charge bottom region.

2.2.1 Preliminary Breakdown

Preliminary breakdown pulse of PBP is known as a process in the cloud where the initial of the stepped leader occur. Basically, this breakdown process is happen when the main negative charges in the cloud is interact with the positive charge region or known as positive charge pocket. Besides that, there are many factors why it happen such as humidity, pressure and latitude properties. Preliminary breakdown pulse can be seen when the waveform is measured as shown in Figure 2.2. The scale of time of this breakdown range to μs refers as electromagnetic field.

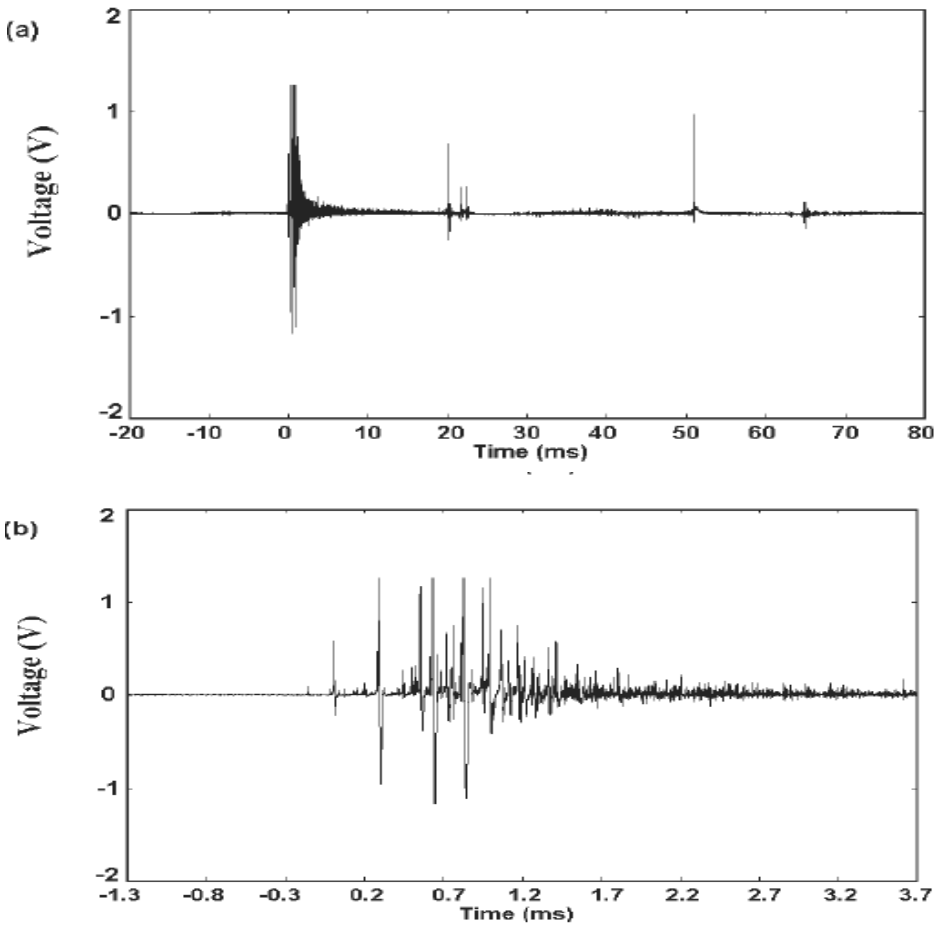

Figure 2.2: Preliminary Breakdown Pulse

2.2.2 Stepped Leader

The stepped leader occur after the preliminary breakdown . This CG stepped leader believed will propagate toward the most positive charged area. The stepped leader is propagate discontinuously and charged exhibit with many branches. According to (Schonland et al., 1938) stepped leader speed value is $2x10^5$ ms^{-1} over few kilometers and accelerates when it approach the ground. Figure 2.3 shows diagram of stepped leader.

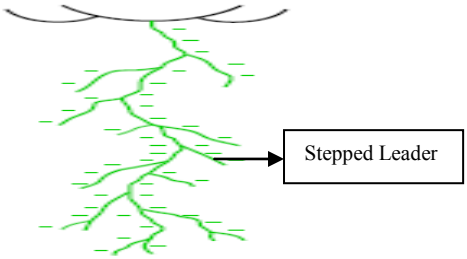

Figure 2.3: Stepped Leader Diagram

2.3 Type of Lightning

There are three primary forms of lightning discharge.

2.3.1 Cloud-to-Ground

This is the archetypal type of lightning exist when the negative charge discharge to the ground. There is also negative flashes when lower positive charge to ground. (Rakov, V.A., et al 2003) identify that 90% of global flashes are transport of negative charge to ground. The peak current first return stroke is about 30kA. This type of lightning believe that damaging and effect mankind the most.

This thesis will be focus on more negative CG. Based on (Baharudin, Z. A, 2014), tropical country as Malaysia and Sweden examine 1687 negative cloud to ground. The picture of cloud-to ground lightning shown in Figure 2.4.

Figure 2.4: Cloud-to-ground.

2.3.2 Intracloud Lightning

Intracloud lightning (IC) often occurs to the interior of the cloud when the storm cloud is vertically discharge between dipolar positive and negative charge. Normally, it can be observe at night. According to (Krehbiel, P. R, 1968), the common IC lightning that happen is horizontal, particularly in large storm system where lightning may propagate over distance of 100 km or more. Figure 2.5 shown the intracloud lightning event.

Figure 2.5 : Intracloud