UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CONTROLLING THE ASSOCIATION OF LIGHTNING ELECTROSTATIC FIELD IN LIGHTNING RADIATION FIELD MEASUREMENT SYSTEM

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

by

RUSMINURLAH FAIZZUAN BIN RAZMI

B071310650

940502-11-5183

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **CONTROLLING THE ASSOCIATION OF LIGHTNING ELECTROSTATIC FIELD IN LIGHTNING RADIATION FIELD MEASUREMENT SYSTEM**

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Date :

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with (Hons.). The member of the supervisory is as follow:

……

(Dr. Zikri Abadi Bin Baharudin)

ABSTRAK

Kilat adalah fenomena alam semula jadi yang paling hebat umumnya dikenali sebagai panahan kilat. Panahan kilat menjana medan elektrik dianggap sebagai frekuensi yang beradiasi tinggi dan rendah. Tujuan projek ini adalah untuk mengautomasikan operasi litar RC semasa kilat berlaku dalam jarak dekat dengan menggunakan Arduino Uno. Projek ini membenarkan isyarat untuk mempunyai struktur mekanisma kecil semasa kilat berlaku dalam jarak dekat. Dengan menukar masa pereputan yang berterusan ia akan menghasilkan isyarat yang bersih tanpa ganguan medan elektrostatik apabila kilat berlaku pada jarak yang kurang daripada 30 km. Eksperimen ini dilakukan dengan menggunakan plat rata dan cambuk plat antena yang akan digunakan untuk mengesan hasil voltan yang disebabkan oleh panahan kilat, maka voltan teraruh dihantar kepada isyarat kawalan litar, litar ini terdiri daripada litar RC dan voltan pengikut untuk mengawal isyarat di antara antena dan perakam sementara. Kemudian profil isyarat kilat akan dipaparkan pada osiloskop untuk dianalisis. Pengukuran ini dijalankan di Fakulti Kejuruteraan Elektrik, Universiti Teknikal Malaysia Melaka. Analisa ini telah dilakukan dengan memberi tumpuan kepada ciri-ciri awan negatif ke tanah. Selain itu, kilat adalah unik dan sukar untuk difahami. Jadi, maklumat lanjut dan peralatan terkini yang diperlukan untuk persediaan untuk kajian masa depan.

Kata kunci- Medan elektrik, plat rata dan plat cambuk antena, jauh dan dekat jarak kilat

ABSTRACT

Lightning is the most fabulous nature phenomena generally known as lightning flashes. The lightning flashes generate electric field considered as radiations which are high and low frequency radiation. The purpose of this project is to automate the operation of RC circuit during lightning closed event by using the Arduino Uno. This project allowed to have a small structure of lightning mechanism during closed event activities. By changing the decay time constant it will produced a clean signal without association of electrostatic field when lightning occurred at the distance less than 30 km. The experiment was conduct by using the flat plate and whip plate antenna that will used to sense the induced voltage produce by lightning flashes, then the induced voltage is sent to the circuit control signal, this circuit consist of the RC circuit and voltage follower to control the signal between antenna and transient recorder. Then the signal profile of lightning will display on oscilloscope to be analyzed. The measurement was conducted at Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka. The analysis had been done by focusing on the characteristics of negative cloud to ground. Besides that, lightning strike were unique and difficult to understand. So, more information and latest equipment needed for preparation for future research.

Keyword- Electric field, Flat plate and whip plate antenna, near and far range lightning occurs.

DEDICATION

To my beloved parents,

Mr Razmi and Mdm. Rusilawati,

Whom was raised me,

Accompany me,

Cheer me,

Feed me,

I love you both.

ACKNOWLEDGEMENT

In the Name of Allah, the Most Beneficent, the Most Merciful.

I am heartily thankful to my dedicated supervisor, Dr Zikri Abadi Bin Baharudin who has guide and taught me regarding the project "Controlling the association of lightning electrostatic field in lightning radiation field measurement system" with his patience, courage and experience.

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Last but not least to my both of panels that have spent time to read my thesis, attend seminar presentation and give comment to improve myself in future.

Alhamdulillah.
(All praise to Allah Almighty)

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CG	-	Cloud-to-Ground
LPCR	-	Low Positive Charge Region
PBP	-	Preliminary Breakdown Pulse
SL	-	Stepped Leader
RS	-	Return Stroke
NBPs	-	Narrow Bipolar Pulse
NNBPs	-	Narrow Negative Bipolar Pulse
RF	-	Radio Frequency
Slow E	-	Electrostatic
Fast E	-	Radiation

CHAPTER 1
INTRODUCTION

1.0 Introduction

This section will be reviewed about the main idea of this project. This section explained about the problem statement, objective and the purpose of this project. Generally, the purpose of the project is to controlling the association of lightning electrostatic field in lightning radiation field measurement system.

1.1 Background

In electricity field, the lightning flashes are a very common because many researcher have doing test or experiment to prove that it produced electrical discharge. The research have been done by Benjamin Franklin and proven that the lightning is an electrical discharge (Anon n.d.). In each of the cloud it will bring the several characteristic of the lightning depend at the place that the measurement was taken. This natural phenomenon is the things that we are unable to expect when it will happen and what are the lightning characteristics. Characterization of electric field from electromagnetic field measurement is still considered an important tool (Baharudin 2014a). Although, it can be conclude that at the return stroke is very important for further research because due to very high frequency at very fast reaction that can harm the sensitive equipment.

Lightning is caused by the electrostatic charge in clouds. Electrostatic is known as slow moving electric charge. One region within the cloud builds up a

positively charged and the other is a negatively charged. The process is not completely understood as to why, but the bottom of the cloud usually ends up being negatively charged and the top positively charged. When the electrical potential difference between the positive and negative charge is great enough, the electrical field cause the air to ionize and allowing the spark. A whip antenna was used to sense the slow field signal. Besides that, the electrostatic field is generally dominant at closed range.

The lightning flashes will generate electric field considered as radiation which are high and low frequency radiation. The sub-process may radiate very differently depend on the frequency. Although, negative flashes are only one type of discharge mechanism and positive flashes have different leader mechanism than negative flashes(Reads 2016). Therefore, because it decreases as 1/R, the radiation field is the only field component observed at long range beyond a few 10s of kilometers. The radiation field also dominates at the very beginning of a return stroke because peak d I/d t occurs very early in a return stroke discharge.

This project will focus on controlling the association of lightning electrostatics field in lightning radiation field measurement. The electrostatic become dominant at closed range. Therefore, it is important to provide such a system to compensate the effect of electrostatics field in the lightning detection system. The idea of this project is to compensate this problem by changing the decay time constant of radiation field sensor, automatically.

1.2 Problem Statement

Lightning generated electric field measurement can be classify into two categories. Firstly, electrostatic field or also known as slow field. Secondly, radiation electric field or fast field. The problem issue related to our study is regarding on the distance effect of lightning strike or the distance between lightning strike point and measurement station.

Lightning radiation field measurement is used to determine the profile of lightning for the distance between 30km to 100km. However if the distance of measurement is less than 30km, the electrostatics field become dominant thus cause the association electrostatics field signal to the radiation field measurement. The electrostatics field become effect to the lightning radiation signal field measurement. This effect will cause the misidentification of lightning detection system because of the change profile of lightning data due to association effect.

1.3 Project Objective

The objective is a purpose of the project. The objectives of this project are:

I. Identify the profile of the association of electrostatic field in radiation field measurement.

II. Modified the decay time constant of radiation field by reducing the value of resistor.

III. Automate the operation of RC circuit during lightning close event by using the Arduino Uno.

1.4 Project Scope

This project scope will be focused on the characteristic of lightning negative cloud to ground because the geographical of Malaysia influence this type of lightning almost happened in Malaysia.

Make the measurement with electronic instrumentation by modified of RC circuit. A combination of RC-circuit and voltage follower acted as a drive circuit to control the signal between the antenna and transient recorder through the coaxial cables.

Study the lightning generated radiation electric field (fast field) for the distance of 1-30 km to know their profile of lightning. For the hardware construction the parallel flat plate antennas were used to detect fast electric field and the whip antennas were used to detect slow electric field signal.

Besides that, investigate the lightning mechanism between preliminary breakdown processes and return stroke. The data collected will be analyzed or record to compare the data with others.

1.5 Report Outline

Chapter 1 presents the introduction of the project title of controlling the association of lightning electrostatic field in lightning radiation field measurement system. This chapter also describes the background history, problem statement, objectives, and scope of the project.

Chapter 2 explain the literature review on previous thesis, study about lightning phenomena and measurement the distance of lightning.

Chapter 3 is a methodology chapter where the information about the procedure and the lists of hardware to conduct the project is described.

Chapter 4 is the data analysis and discussion is where the data are analyzed and discussed.

Chapter 5 is the conclusion and recommendation is the last chapter that concludes about the whole project and suggest some recommendations in improving this thesis in the future.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter discuss about the lightning terminology, radiation and electrostatic. It also highlight some previous case studies that can related to this project from reference book, thesis and journal. Lightning is a very huge electrostatic that always happen between the cloud to ground, cloud to cloud or within cloud and it is the natural phenomena. So, that it is very important to have a good knowledge and information about on the initiation process of the lightning.

2.1 Lightning Discharge

The lightning discharge of the electricity in the cloud cause a thunderstorm. Basically, one region is negative charge and one region is positive charge. Besides that, the interior of the storm cloud contain dipolar charge that divided into the positive charge uppermost region, followed by the negative charge region at it is center, and an additional small pocket of positive charge or also known as Low Positive Charge Region (LPCR) at the bottom of the cloud. When the interaction of negative charge and LCPR occurs, the electricity in the cloud will discharge to the ground and charge will emits light that is called lightning. Figure 2.1 above shows an example of the probable distribution of cloud charges adapted from the measurements obtained by Malan.

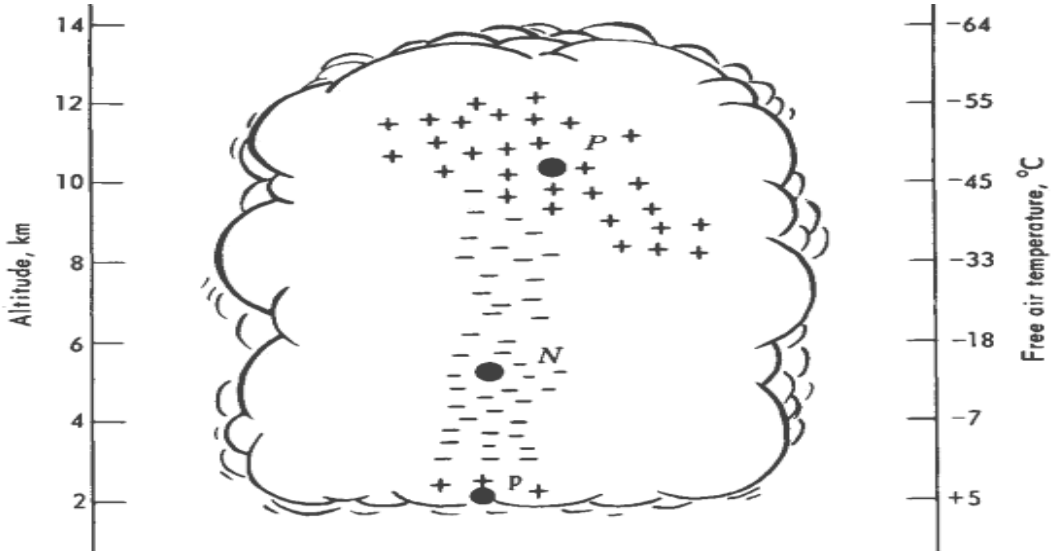

Figure 2.1: Thundercloud charge, P-positive charge uppermost region, N-negative charge region and P-low positive charge region.
(Adapted from (Rakov 2013))

2.2 Preliminary Breakdown

PBP or preliminary breakdown pulse is known as an initial process of the stepped leader occurs. This breakdown is thought to arise from the interaction between the main negative charge and LPCR. The preliminary breakdown process in ground flashes can be seen when the waveform is measured as shown in figure 2.2. This process usually produces a train pulse with μs-scale-electric field pulses.

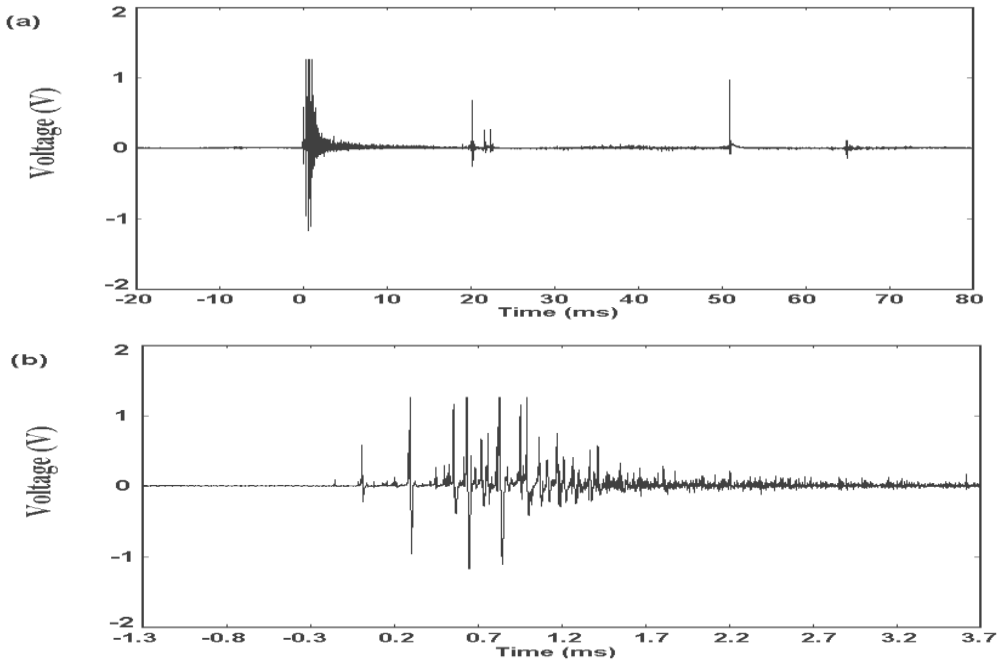

Figure 2.2: Example of electric field due to negative ground flashes of preliminary breakdown pulse.
(Adapted from (Anon n.d.)(Baharudin 2014b))

2.3 Type of Lightning

Lightning can be divided mainly into two types namely, cloud to ground discharges (CGs) and cloud flashes (ICs). When lightning strikes the ground or the object at the ground, it is called a ground discharges (CGs). (Service n.d.) (Is & Revised n.d.)

The types of ground flashes can be seen into two terms. Firstly, the polarity of the charge within the cloud from the situation that the leader is began or the place where it propagates. Secondly, the direction of the leader. Additionally it is observed that the part of polarity downward and upward denotes the polarity of the resultant current to the ground.

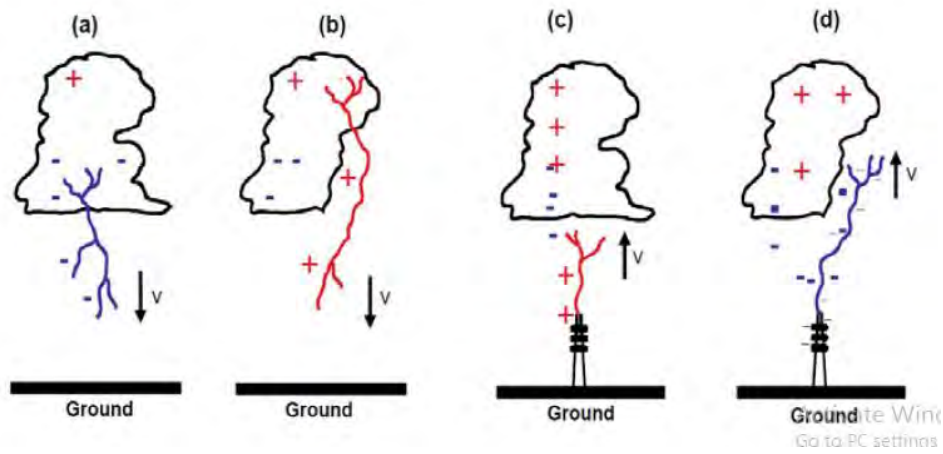

Figure 2.3.1: Type of cloud to ground lightning flash

(Adapted from (Baharudin 2014b))

There are 4 type of cloud to ground lightning flash in figure 2.3:

(a) Downward negative lightning

(b) Downward positive lightning

(c) Upward negative lightning

(d) Upward positive lightning

The downward negative lightning transports negative charges from the cloud to the ground and account for 90 % of ground discharges. The other 10 % of ground discharges are downward positive lightning which transport positive charges from the cloud to the ground. Even though positive CGs constitute only 10 % of the discharges, they are consistently related with the highest peak current (~300 kA) and biggest charge transfers to ground (hundreds of Coulombs). Upward lightning, as opposed to the downward lightning most often arise as a result of presence of tall object (greater than 150 meter). This type of flashes has been found to move more usually negative charges than positive charges to ground.

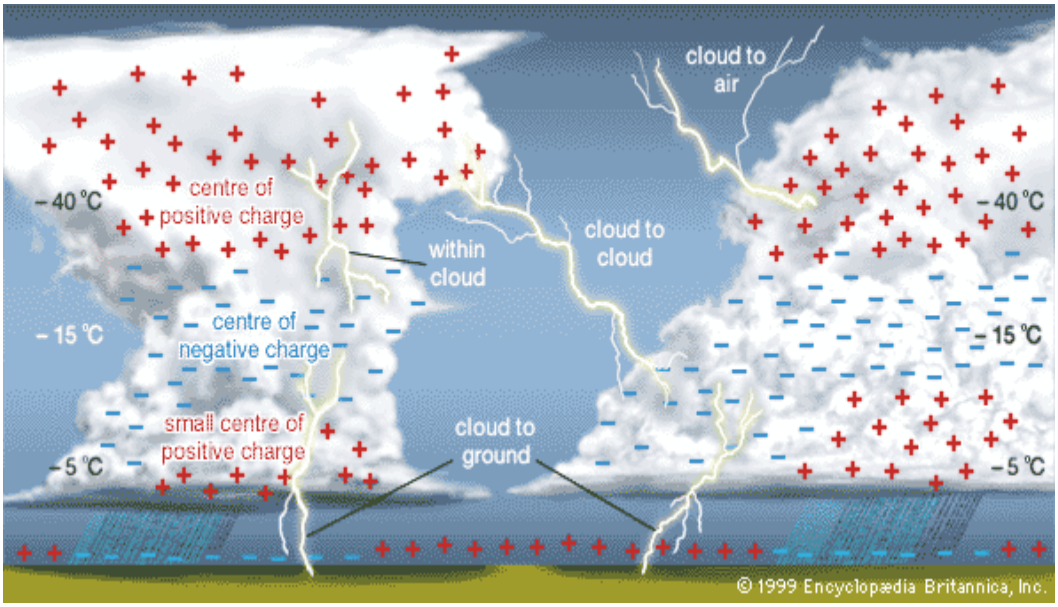

Figure 2.3.2: Electric charges distribution inside of a thundercloud and the region of the place lightning can arise.
(Adapted from (Anon n.d.))

2.4 Stepped Leader and Return Stroke

Characteristics of lightning.(Rakov 2013) (Baharudin 2014b)

2.4.1 Stepped Leader

Before the lightning strike to the ground, there was once the first process occurs in the cloud that's call preliminary breakdown. When the ionization of the atom in the cloud gained the electron (negative ions) and it's going to emerge as electrically charged. When there was quite strong value of negative charge in the cloud, so that it will produce the electric fields and will caused negative charge to be propelled downward to the earth. This phenomenon is referred to as stepped leader considering it appear downward to the earth. The stepped leader from the cloud come downward to the ground can also be classification as a series of branches or steps.