UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE MEASUREMENT OF BROADBAND RADIATION FIELD GENERATED BY LIGHTNING FOR DETERMINATION OF LIGHTNING STRIKE DISTANCE

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

by

MUHAMMAD AKMAL BIN BAHARI
B071210068
930604-02-5593

FACULTY OF ENGINEERING TECHNOLOGY
2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **The Measurement Of Broadband Radiation Field Generated By Lightning For Determination Of Lightning Strike Distance**

SESI PENGAJIAN: **2015/16 Semester 1**

Saya **MUHAMMAD AKMAL BIN BAHARI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TERHAD	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TIDAK TERHAD	

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:

Kampung Bemban Mukim Gelong

06000, Jitra

Kedah Darul Aman.

Cop Rasmi:

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "The Measurement of Broadband Radiation Generated by Lightning for Determination of Lightning Strike Distance" is the results of my own research except as cited in references.

Signature **:……**

Name **: MUHAMMAD AKMAL BIN BAHARI**

Date **: 9 DECEMBER 2015**

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) (Hons.). The member of the supervisory is as follow:

…….

(Dr. Zikri Abadi Bin Baharudin)

ABSTRACT

Dangerous is a word to describe a lightning strike effect towards human, animal and environment. A lightning strike can blows a fatality to human and causes death. Besides that, lightning strike has potential to damage property especially the transmission tower and reduces the performance of our power system transmission. Lightning cannot be diminished yet controlled by human but human can reduce the risk from getting struck to avoid the lightning by keeping a safe distance from the lightning activities area. The purpose of this project was to measure the distance of the lightning strikes. The project focused on to measure the broadband radiation generated by lightning for determination of lightning strike distance takes place in Melaka, Malaysia. The measurement conducted by using a flat-plate antenna to capture the electric field waveform of the cloud-to-ground (CG) flashes. THS4631 was used in this project as an amplifier. The electric field signal transmitted by using coaxial cables with 50 Ohm impedance. Then the electric field waveform displayed on the Teledyne LeCroy oscilloscope to be analysed. Technique of Time-of-Arrival (TOA) was used to calculate the distance of lightning strike by using delay time of arrival between the electric field antenna and magnetic field antenna. From the result, the lightning activities were detected in the range from 0.5km to 50km from the measuring station. However, lightning strikes were very unique and difficult to understand and more information and equipment needed for preparation for future research.

Keywords **– Lightning distance, Electric field, THS4631, Flat-plate antenna.**

ABSTRAK

Bahaya ialah satu perkataan yang sesuai digunakan untuk menggambarkan tentang kesan panahan kilat terhadap manusia, haiwan dan alam sekitar. Kesan panahan kilat terhadap manusia dapat membawa maut. Selain itu, panahan kilat berupaya untuk merosakkan menara pencawang elektrik dan memberikan kesan dengan mengurangkan prestasi terhadap sistem bekalan kuasa. Kilat tidak dapat dihapuskan dan dikawal oleh manusia tetapi manusia dapat mengawasi diri dengan tidak berada dekat dengan kawasan panahan kilat. Tujuan projek ini adalah untuk menentukan jarak panahan kilat berdasarkan kadar radiasi yang dihasilkan oleh panahan kilat. Projek ini memfokuskan terhadap penentuan jarak panahan kilat berdasarkan kadar radiasi yang dihasilkan di sekitar Melaka, Malaysia. Jarak kilat dapat ditentukan dengan menggunakan antena jenis leper dan rata untuk mengesan gelombang medan elektrik yang dihasilkan oleh jenis kilat yang terpancar dari awan ke tanah. THS4631 merupakan sejenis litar bersepadu yang digunakan dalam projek ini. Gelombang medan elektrik yang dikesan dihantar melalui kabel sepaksi 50 Ohm. Selepas itu, gelombang medan elektrik dipaparkan pada skrin osiloskop Teledyne LeCroy untuk dikaji. Teknik "Time-of-Arrival (TOA)" digunakan untuk menetukan jarak panahan kilat dengan menggunakan kadar masa diantara antena medan elektrik dan juga antena medan magnet. Panahan kilat dapat dikesan dalam lingkungan jarak daripada 0.5 km sehingga 50 km berdasarkan hasil kajian. Walaupun begitu, ciri- ciri panahan kilat sangat unik dan susah untuk difahami dan memerlukan lebih banyak ilmu dan pengetahuan beserta alatan yang perlu digunakan untuk kajian pada masa hadapan.

***Kata Kunci* – Jarak kilat, Medan elektrik , THS4631, Antenna Leper**

DEDICATIONS

To my beloved parents,

Mr. Bahari and Mdm. Kamariah,

Whom was raised me,

Feed me,

Accompany me,

Cheer me,

I love you both.

ACKNOWLEDGMENTS

Alhamdulliah, all praises to God.

I would like to thank you to all those who provided me the possibility in completing the report. A particular thanks goes to my valuable supervisor, Dr. Zikri Abadi Bin Baharudin for his advice and truthful assistance with obligatory information regarding the project "The Measurement of Broadband Radiation Generated by Lightning for Determination of Lightning Strike Distance".

Besides that, my deepest gratitude for my parents Mr Bahari Bin Ali and Madam Kamariah Binti Nayan and the rest of my family for giving me their fullest support, understanding and patience. Without them, I would not be able to finish this project.

Finally, I would like to thanks to all my BETI friends for the brilliant ideas and tips throughout the project in this semester.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF SYMBOLS AND ABBREVIATIONS

CC	=	Cloud-to-Cloud
IC	=	Intra-Cloud
CG	=	Cloud-to-Ground
PBP	=	Preliminary Breakdown Pulse
RS	=	First Return Stroke
SRS	=	Subsequent Return Stroke
PCB	=	Printed Circuit Board
EF	=	Electric Field
MF	=	Magnetic Field

CHAPTER 1
INTRODUCTION

1.0 Introduction

This section comprises about the main idea of whole project. This section explained about the main objectives and the scopes of this project which are determine the purpose of this project. Generally, the purpose of the project is to determine the lightning strike distance by the radiation of the lightning strike.

1.1 Background

The project is about to measure the radiation of the lightning strike by the determination of lightning strike distance. A lightning phenomena often happens in Malaysia. As a country that has a tropical whether, Malaysia has a moisture layer of air which is a perfect medium for the path of the lightning strikes. Lightning or flashes is an electrostatic discharge that may occurs between cloud and another cloud (CC lightning), electrically charged regions of a cloud (IC lightning) or cloud and ground (CG lightning).The lightning strike is an action of the equalization of a different charged regions within the atmosphere and the object on the ground through the air by striking an object on the ground. The lightning strikes produce a broadband radiation of waveform on the air like a bell-shape. A lightning detector can be able to detect and record the lightning strikes depends on the radiation of the waveform produced. The waveform needs to be analysed to determine the location of the lightning strike. Therefore, some measurement methods and calculations need to be used to determine the distance of these lightning strikes.

1.2 Problem Statement

There are many problems brought by the lightning strikes. The lightning strike contains high amount of voltage in the lightning. There are several problem due to the lightning occurrences such as:

1) The lightning strike always damages the transmission tower. Thus, there will needs many maintenance to repair the damaged transmission tower.
2) The lightning strike can be harmful towards human. The lightning can blows a fatal strike to human which leads to death.
3) The damages of the property. The electronic appliances such as television, computers, refrigerator and others may easily damage by the lightning strike.

If there is a lightning detector system, all the negative effect causes by the lightning may be reduced. Therefore, the lightning detection system is an essential for this world to minimize the damages by this phenomenon.

1.3 Project Objectives

The objective is a purpose of the project. This part gives a brief explanation about the purpose on how to determine the distance of the lightning strike.

There are three mains objectives of this project:

i) To construct the hardware for measuring the broadband radiation field generated by lightning for determination of lightning strike distance.
ii) To determine the characteristics of the broadband radiation field generated by lightning for determination of lightning strike distance.
iii) To measure the broadband radiation field generated by lightning for determination of lightning strike distance.

1.4 Objectives of Research

The scope is a specific objectives of the project. This part gives a specified information about how the project will be done.

There are three scopes in this projects:

i) To produce a design circuit using THS4631 for measuring the electric field generated by lightning for determination of lightning strike distance using ORCAD PCB design.

ii) To determine the properties of waveform generated by Cloud-to-Ground (CG) flashes of the first return stroke captured by the flat-plate antenna.

iii) To measure the distance of CG flashes based on the broadband radiation generated by CG flashes in Melaka.

1.5 Significance of the project

The project is significance because the lightning is very hazardous for all human being and property. The lightning detector system can help human to take some safety precautions before doing some specific work which is related to the lightning strikes for examples,

1) A company that holds a contract to build the high voltage transmission tower can measures the intensity of the lightning strikes occur by using this system. This can reduce the probability of the transmission tower being hit by the lightning strike and can saves the cost of the maintenance to replace the surge arrester that may be broken down due to the lightning strikes.
2) A golfer that playing the sport in a wide area can use this system to warn them about the activity of the lightning strikes. They should stop from playing and can move to the safe area where the probability of being struck by a lightning strike can be avoided such as under a building.

1.6 Organisation

This report contains three chapters. Firstly, the reports begin with the Chapter 1: Introduction that introduces about the background of the project, problem statement, project objectives, project scopes and significance of the project. Secondly, this report continues with Chapter 2: Literature Review. This chapter contains basic information about the whole project. It is basically gives the main idea about the related theories and the previous research that completed by other researchers. Thirdly, this report continues with the Chapter 3: Methodology. The Methodology is a chapter where the information about the procedure and the lists of hardware to conduct the project is described. Fourthly, the Chapter 4: Data Analysis and Discussion is where the data are analysed and discussed. Lastly, the Chapter 5: 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
THEORETICAL BACKGROUND

2.0 Introduction

The literature review of this project involves materials from journal, research paper, books and internet. The lightning phenomena occurs because of the charged particles moving or attracting of each other. The literature study will bring together the concept of electric field, lightning phenomena and the law of voltage induction.

2.1 Electric Field

Electric field plays an important role in the lightning occurrences. It is one of the element that involves in the lightning phenomena.

2.1.1 Characteristics of Proton and Electron

The proton and electron are charged particles. The proton carries positive charged particle while the electron is a negative charged particle. The properties of the positive test charge will radially move outward in contrary with the negative test charge which is move radially in toward the point charge. The different charged particles will attracts each other while the same charged particles will repel each other.

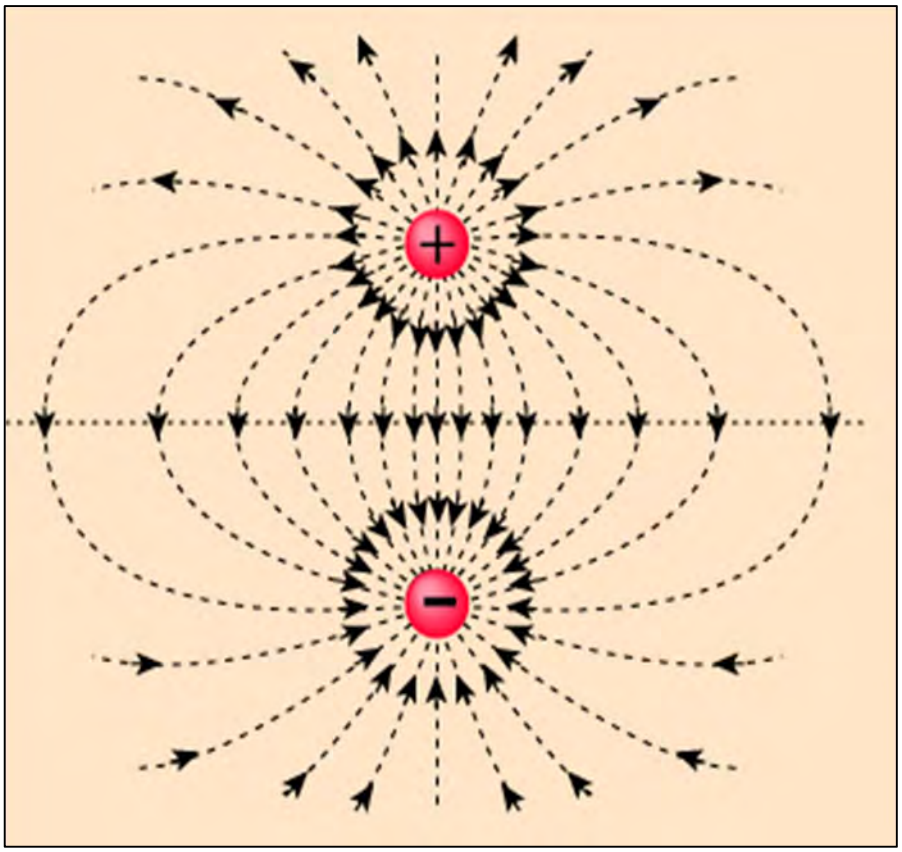

Figure 2.1: The attraction of the positive test charge and a negative test charge
(Source: <http//www.hyperphysics.phy-astr.gsu.edu>[20/5/15])

Figure 2.1 shows the example of reaction between the different charged particles. Electric field of the positive test charge is attracted towards the negative charged particle.

2.1.2 Relationship of Electric Field with Lightning

The cloud contains the negative and positive charged particles. The charges begin to separate within the cloud creating the electric field between the upper cloud and the lower cloud regions. The higher the separation between positive charges and negative charges, the higher the strength of the electric field. The atmosphere is a good insulator that prevents the electric flow from discharged to the ground. When a remarkable amount of charges are cumulated, the electric flow can be discharged to

the ground. This is because the strength of the electric field has overcome the atmosphere's insulator threshold. This is when the lightning phenomena occurs.

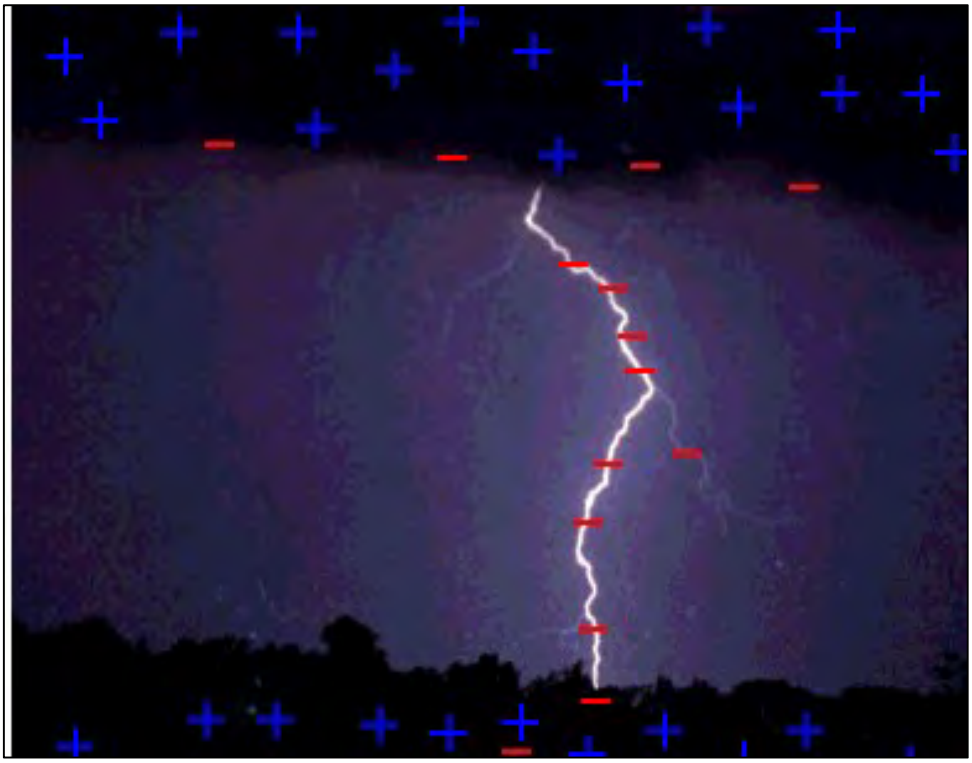

Figure 2.2: The figure shows a bolt of lightning strike.
(Source: <http// www.regentsprep.org>[21/05/15])

.

2.1.3 Relationship of Electric Field with Electromagnetic Field

Electric field is a component of the electromagnetic field. Basically, a moving charge oscillating produce electric field and magnetic field are electromagnetic wave. The electromagnetic wave carry the energy from the electric field and magnetic field in the right angle plane. In other words, the summation of the electric field energy and magnetic field energy is the total energy that carried by an electromagnetic wave. The frequency of the electromagnetic wave depends on the speed of light and wavelength of the radiation. This can be concluded as the energy of the electromagnetic wave is the proportional to the frequency of the wave connected via the speed of light.

$C=f\lambda$ (2.1)

C: speed of light (m/s);

f: frequency (Hz); and

λ: the wavelength (m).

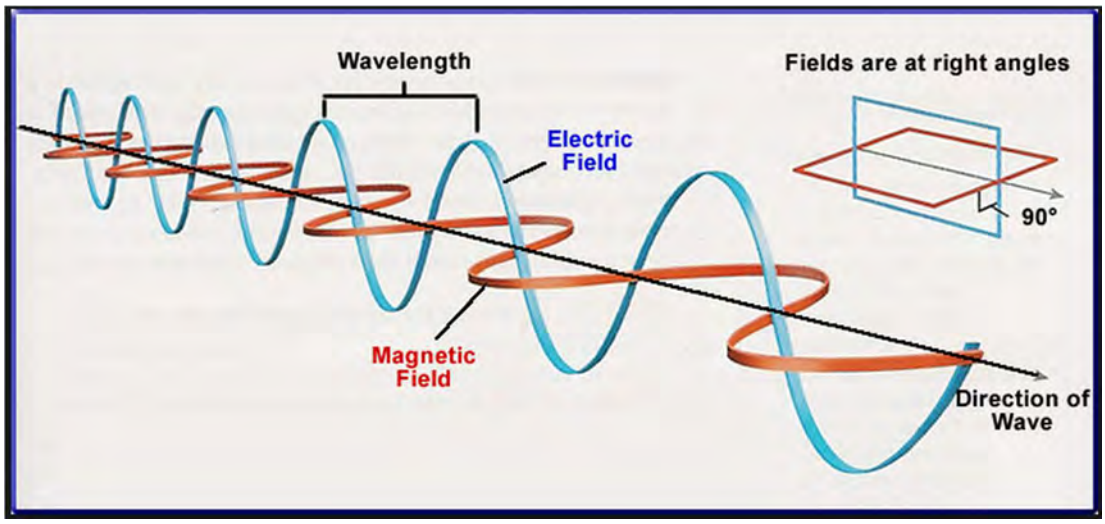

Figure 2.3: The diagram of relationship of electric field and electromagnetic wave.
(Source: <http//www.pixgood.com>[21/05/15])

The Figure 2.3 shows the electromagnetic wave properties. It contains the electric field, magnetic field and the wavelength of wave.

2.1.4 Michael Faraday`s Law of Induction

Michael Faraday was a man that conducted an experiment about the electromagnetism around 1831. He was a first physicist that introduced the law of electromagnetism induction. He stated that any change in the magnetic environment of a coil wire will cause a voltage to be induced in the coil. This concept can be used to induce the voltage through the coil as viewed in BBC History website at <http://www.bbc.co.uk/history/historic_figures/faraday_michael.shtml>.

Any movement in electromagnetic field can creates a certain amount of voltage depending on the strength of the electromagnetic field. Towards his concept, the voltage can be create to be as a signal input to measure the distance of the lightning with appropriate hardware setup.

2.2 Discovery of Lightning Phenomena

In the remotest times, Franklin discovered that lightning interruption on expanding electric power systems formed comprehensive study of the lightning phenomena was crucial. He was using the kite with the attached key and tied it to a post with a silk thread. As time passed, Franklin sensed the loose fibres on the string stretching out and touched the key. Then, he saw a spark jumped the gap showed that lightning was a discharge of static electricity. Many researchers had taken interest with this phenomena. They conducted numerous of experiments to study about the lightning natures. This phenomena appears because when the electric field becomes strong, the bolt of lightning will arises between clouds and the ground. The electrical discharge continually superheats the discharge channel making the air to expand and produce a wave as thunder.

2.2.1 Types of Lightning

There are variant types of the lightning strikes. Lightning and lightning discharges within a cloud are usually termed “lightning flashes or simply called “flashes”. They can be intra-cloud (IC), cloud-to-cloud (CC), cloud-to-ground (CG). The name tells the nature as the CC Lightning is the interaction of the electrical charges between one cloud with another, CG Lightning is exists between the cloud and the ground while IC Lightning is the electrical discharges by the cloud itself (Z.A. Baharudin, 2014).