UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DETERMINATION OF LIGHTNING DISTANCE FROM THUNDER AND RADIATION ELECTRIC FIELD

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

by

MUHAMMAD HILMI BIN YAHYA

B071410142

921013-06-5011

FACULTY OF ENGINEERING TECHNOLOGY

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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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 Honours. The member of the supervisory is as follow:

……

(Dr. Zikri Abadi Bin Baharudin)

ABSTRAK

Tujuan projek ini adalah untuk mengenalpasti jenis kilat yang diklasifikasikan sebagai kilat yang paling bahaya iaitu kilat awan-ke-darat dimana kilat ini di antara kilat-kilat yang mampu memusnahkan harta benda dan berbahaya kepada kehidupan dimana kilat ini boleh menyebabkan kecederaan dan kematian. Bagi menentukan jenis kilat ini satu kaedah digunakan didalam projek ini ialah masa-ke-guruh bagi menentukan beza masa di antara sinaran kilat dengan bunyi guruh. Kaedah ini dilaksanakan dengan menggunakan dua teknik ukuran iaitu bidang radiasi elektrik jalur lebar dan akustik guruh rakaman isyarat. Masa yang berlalu antara sensor digunakan untuk mengira jarak kilat. Perisian XViewer 1.81 (Yokogawa) digunakan untuk kerja-kera analisis maklumat. Berdasarkan keputusan, purata jarak adalah antara 3 km dan 9 km. Daripada projek ini, kemampuan mikrofon yang diguna dapat mengesan tenaga yang berlaku semasa radiasi medan elektrik selain mengesan saluran akustik. Kesimpulannya, keseluruhan objektif berjaya dicapai tetapi penambahbaikan perlu dilakukan untuk meningkatkan tahap ketepatan data yang akan diperoleh pada masa hadapan.

Kata kunci: Jarak Kilat; Masa-ke-Guruh; Beza Masa

ABSTRACT

The purpose of this project is to identify the type of flash that is classified as the most dangerous cloud-to-ground lightning where the flash is among lightning flashes that can destroy property and harm to life where lightning can cause injury and death. To determine this type of lightning, one method used in this project is time-to-thunder to determine the difference in time between lightning radiation and thunder sounds. This concept was adapted by using two measurements techniques is broadband electric radiation field and the acoustic signal recording thunder. The time elapse between sensor was used to calculate the lightning distance. The XViewer 1.72 (Yokogawa) software used for analysis work. Based on the results, the average distance is between 3 km and 9 km. From this project, the ability of the microphone to be used to detect the energy that occurred during the radiation of the electric field besides detecting acoustic channel. In conclusion, the overall objective is achieved but improvements have to be made to improve the accuracy of the data to be obtained in the future.

Keywords: Lightning Distance; Time-to-Thunder; Time Elapse

DEDICATION

To my beloved mother and father, my family, my lecturers and my fellow friends, thank you for being supportive person and help given to me on completing this project.

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J	-	Joule
dt	-	time different
N	-	Newton
dB	-	Decibel
Km	-	kilo meter
V	-	Volt
µsec	-	micro second
LPCR	-	Low Positive Charge Region
C	-	Coulomb
℃	-	Celsius
kA	-	kilo Ampere
BIL	-	Breakdown, Intermediate, Leader
Ms	-	mile second
CG	-	Cloud-to-Ground
ms^{-1}	-	Speed
PC	-	Personal Computer
IC	-	Integrated Circuit
α	-	Alpha
Hz	-	Hertz
%	-	Percentage
Ns	-	Nano second
Sec	-	second
NCG	-	Negative Cloud-to-Ground
PCG	-	Positive Cloud-to-Ground
CA	-	Cloud-to-Air Lightning
CC	-	Cloud-to-Cloud Lightning

P	-	Positive
N	-	Negative
GC	-	Ground-to-Cloud
K	-	Kelvin
γ	-	Gamma
Ω	-	Ohm
F	-	Farad
UTeM	-	Universiti Teknikal Malaysia Melaka
USB	-	Universal Serial Bus
DC	-	Direct Current
AC	-	Alternating Current
PWM	-	Pulse Width Modulation

CHAPTER 1
INTRODUCTION

1.0 Introduction

In this chapter, it will concise all the primary subjects of the project that consist the project background, problem statement, objective, project scope, importance of project and significant study. Overall of this project is to determine the lightning distance from thunder and radiation electric field.

1.1 Project Background

Lightning is the most interesting phenomena that occur in the universe. The discoverable of this nature is remain a mystery and never settle. Positive and negative charges that contain in the interior of the storm cloud polarized cause lightning strike. During thunderstorm, many processes occur which lead in developing electric charge in various part of the cloud. Some of the processes involve are vertical winds and different water droplet size. During the process of charging the cloud, it will achieve where the cloud is strong enough to discharge it charges that as a stroke of lightning. Figure 1.1 shows the type of thundercloud charge that normally occurs in the cloud and how it is discharged. They are many types of lightning that are cloud-to-ground, ground-to-cloud lightning, intra-cloud lightning, and cloud-to-cloud lightning. But cloud-to-ground is the most famous lightning occurring towards the ground, which be classified as the most dangerous lightning activity that give harm to human and properties.

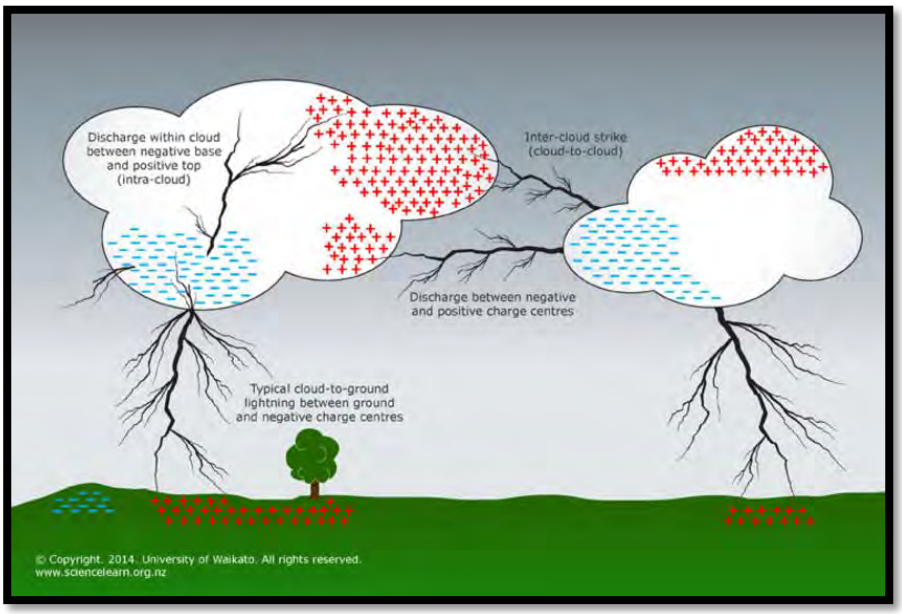

Figure 1.1: Type of Thundercloud Charge adapted from (https://www.sciencelearn.org.nz/resources/239-lightning-explained)

Thunder is the acoustic emission associated along after the lightning discharges. Thunder signatures have been analysed by many scientists that aim of understanding the energy emitted, asymmetric channel, and localization of lightning channel (Bodhika et al. 2014). Thunder is the result of sudden expansion of the air along the lightning channel due to extremely high in temperature of the lightning channel. The sudden increase in pressure and temperature of lightning will produce a rapid expansion of the air surrounding and within a bolt of lightning. The shock wave generated by the lightning transfer the thunder signal within a couple of meters from its source. Larger amplitudes of thunder signatures are usually associated with the return stroke stage with the highest amplitude in lightning profile (Bodhika et al. 2011). The time-to-thunder method was one method to determine the strike distance which aiming for the time lapse of both events (Ibrahim & Malek 2010). Thunder waves generated by lightning cloud-to-ground flash are considered to be one of strong natural sound source. Even though the strongest thunder signatures are generated at the return stroke stage, thunder signals generated at other events also can be strong enough to be record using a sensitive system (Bodhika et al. 2011). Electric field generated by lightning events recorded through wide band from 20 kHz to 20 MHz measurement have been analyses using Fourier methods

by many researchers in the past that was very accurate method to determine the sound of thunder (Sonnadara et al. 2006).

1.2 Problem Statement

A thunder from lightning generation is not well understood. However, some study had identified a certain sound from the thunder can inform a certain type of lightning that is usually cloud-to-ground lightning. In real life, lightning was among the most dangerous natural disasters. There are 100 lightning strikes every second on earth that have enough power to destroy everything within no time. So, the information from both lightning and thunder sound were very important to determine the type of lightning. Besides that, the microphone used to collect the thunder sound, but at the same time the microphone also will collect the radiation electric field when the antenna detects the lightning. Apart from that, the time lapse after a lightning flash to hear thunder sound also not fixed as the lightning occurs with many distances.

1.3 Objective of project

The objective is a purpose of the project. This part gives a brief explanation about the purpose.

There are three main objectives of this project:

a) To evaluate the capability of sound sensor as detecting electric field radiation.
b) To measure the time elapsed between the signature of the first return stroke and thunder sound for determining distance.
c) To analyse the amplitude and the duration of radiation from the unwanted signal statistically.

1.4 Scope of project

The scope of the project should be parallel to the objectives. The concept of the thunder and lightning formation need to be studied for understanding the basic concept of the formation. The microphone used is to identify the capability of sound sensor where it can detect electric field radiation besides is detecting thunder sound. In this project, hardware need to be combined between electric field sensor which is the parallel plate antenna and the thunder sound sensor which is uni-directional outdoor microphone. Form these two sense elements, it can determine the time elapse between lightning and thunder event as the lightning occurs first and followed by the sound of thunder. The lightning type for this research are focused more toward negative cloud-to-ground lightning. The output waveform from this project is to analyse the amplitude and the duration of radiation from electric field radiation, microphone and to analyse the unwanted signal statistically.

1.5 Report outline

In this report, there are five chapters altogether. Chapter 1 gives some introduction, objective and scope of the project. Literature review of this project is included in chapter 2. This chapter reviews the related work that had been done by other people as well as the existing project. Chapter 3 reveals the methodology of completing this project. For chapter 4 is about the result data review and discussion based on the result. Chapter 5 will be conclusion for the project.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

In this chapter, it provides the discussion about the information of lightning and thunder. This includes the discharge process and also upward and downward moving process. Besides that, common type of lightning also explains with the type of thunder sound heard. Time-to-thunder method also being explain with also the distance of thunder can be detected. The process of measurement for lightning and thunder are also will be described.

2.1 Formation Concept

2.1.1 Thunder

Thunder is the sound that cause by lightning strike. Thunder also can be defined as the acoustic radiation associated by lightning (Uman 2001). Any sound is made up of vibration in the air. The vibrations travel as a sound wave through air as the medium, until reach human ear as receiver. As the air heats up during a huge discharge of electricity for formation of lightning, the surrounding air rapidly expands that cause the air particle move apart with each other. During rapid heating and cooling of air near the lightning channel cause a shock wave to vibrate and produces a tremendous crack that heard as thunder. The lights travel quicker to eyes that the sound from lightning. Based on figure 2.7 below,

it is show that the sound of thunder travel much slower compared to light produced by lightning. The speed of lightning is roughly 330 m/sec (Uman 2001). So, thunder sound can travel 3 second for one kilometer that time-to-thunder can be determined.

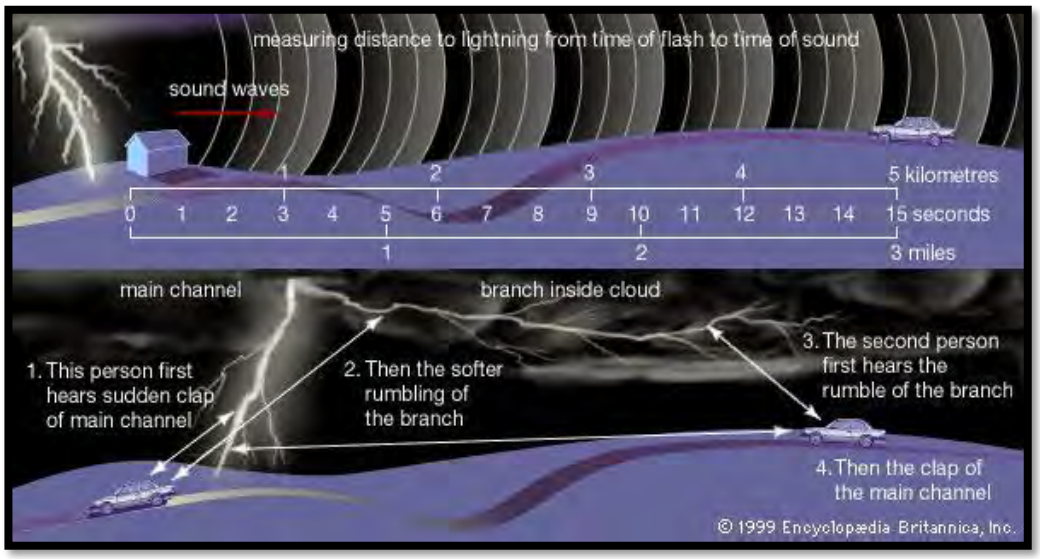

Figure 2.1: The time lapse between lightning flash and thunder sound adapted from (https://www.britannica.com/science/thunderstorm)

Thunder also can be divided into two categories that are audible and infrasonic. Audible is an acoustic sound energy that can be hear human ears during rapidly expanded of heated lightning channel with frequencies greater than 20 Hz. While infrasonic sound thunder is an acoustic sound energy that is below the frequency of human ears can detect that generally a few tens of Hz with frequency below than 20 Hz. The origin of infrasonic thunder sound is the conversion of the energy stored in electrostatic field of the thunder cloud to sound energy when the lightning rapidly reduces the cloud field (Uman 2001).

2.1.2 Lightning

The most general sources of lightning are thundercloud, which is formed by cumulonimbus. Essentially, thundercloud structure was found to be tri-polar