THESIS

DEVELOPMENT OF MATLAB PROGRAM FOR LIGHTNING LOCATION SYSTEM WITH INTERFEROMETRY METHOD

Prepared to Fulfill the Requirements for Obtaining a Bachelor's Degree

Engineering in the Department of Electrical Engineering, Faculty of Engineering

Universitas Sriwijaya

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VALIDITY SHEET

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Signature : 

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The author realizes that there are still many things that could be improved in preparing this thesis. Therefore, constructive criticism and suggestions from all parties are very much expected. Hopefully, this final project can be helpful for all of us.

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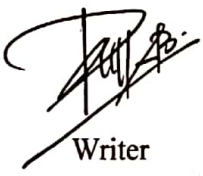

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ABSTRACT

DEVELOPMENT OF MATLAB PROGRAM FOR LIGHTNING LOCATION SYSTEM WITH INTERFEROMETRY METHOD

(Rian Alto Belly, 03041281924122, 2023, xxiI + 48 pages + appendices)

A lightning location system (LLS) is designed to determine the location or estimate of a lightning strike more accurately. It is essential to map areas with high intensity of lightning strikes so that they can be used as a reference in determining protection for specific objects and minimizing losses to both inanimate objects and living things. In this project, the data used is secondary data obtained from the monitoring station for Interferometry lightning activity at Universiti Teknikal Malaysia Melaka (UTeM). The Interferometry method determines the value of the azimuth and elevation angles using the time difference between each Antenna. Lightning data management is done through Matlab software by applying windowing and cross-correlation. To obtain good data, windowing is done with a window size of 128 and an overlap of 16. Cross-correlation is applied to correlate the two signal waves to produce a time delay value for calculating elevation angles and azimuth. As a result, 336 windows were successfully correlated and obtained time delay values so that 336 azimuth and elevation data were successfully plotted on the lightning location map with fluctuating values indicating lightning movement during the lightning strike process.

Key words : Lightning Location System; Interferometry; Matlab; Elevation; Azimuth

ABSTRAK

PENGEMBANGAN PROGRAM MATLAB UNTUK SISTEM LOKASI PETIR DENGAN METODE INTERFEROMETRI

(Rian Alto Belly, 03041281924122, 2023, xxiI + 48 hal. + lampiran)

Sistem lokasi petir atau *Lightning Location System* (LLS) adalah suatu sistem yang dirancang untuk dapat menentukan lokasi atau perkiraan sambaran petir dengan lebih akurat. Ini penting untuk memetakan daerah dengan intensitas sambaran petir yang tinggi sehingga dapat menjadi acuan dalam menentukan perlindungan terhadap objek tertetu dan meminimalisir kerugian baik kepada benda mati dan mahluk hidup. Dalam project ini data yang digunakan adalah jenis data sekunder yang didapat dari stasiun pengawasan aktivitas petir interferometri Universiti Teknikal Malaysia Melaka (UTeM). Metode interferometri menentukan nilai sudut azimuth dan elevasi dengan menggunakan perbedaan waktu yang terjadi antara masing masing antena. Pengelolaan data petir dilakukan melalui software Matlab dengan menerapkan *windowing* dan *cross correlation*. Untuk memeroleh data yang baik dilakukan *windowing* dengan *window size* 128 dan *overlap* 16. *Cross correlation* diterapkan untuk mengkorelasikan dua gelombang signal sehingga menghasilkan nilai perbedaan waktu (*time delay*) untuk perhitungan sudut elevasi dan azimuth. Dihasilkan 336 window yang berhasil dikorelasikan dan memperoleh nilai time delay sehingga dihasilkan 336 data azimut dan elevasi yang berhasil di plot pada peta lokasi petir dengan nilai yang fluktuatif yang menunjukan pergerakan petir selama proses sambaran petir terjadi.

Key words : Sistem Lokasi Petir; Interferometri; Matlab; Elevasi; Azimut

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LIST OF TERMS

Azimuth	:	The azimuth angle is the clockwise angle from North to the value $\mathbf{0° - 360°}$
baseline	:	The distance between the antennas on the lightning location system using the Interferometry method
Bolts From The Blue	:	A faster type of typical IC lightning strike
Cloud to Ground	:	The lightning bolt that occurred from the thundercloud headed towards the ground
Cross-Correlation	:	One of the correlation methods in Matlab
Cumulonimbus	:	(Cb for short) is a towering vertical cloud (D2 family) that is very tall, dense, and involved in thunderstorms and other cold weather
Dipole	:	Use the idea of an electric dipole moment to measure a "polarity" of chemical bonds in a molecule
Directions of Arrival	:	A system that estimates or calculates the angular difference of the VHF electromagnetic field detected by a pair of antennas within a certain distance
Equivalent	:	Value (size, meaning or effect) of the same, worth, comparable, commensurate
ElectricField	:	The region of space around an electrically charged particle or an object in which the charge body experiences the force
electrons	:	Subatomic particles are negatively charged and are often written as e-

electromagnetic	:	A type of magnet in which an electric current generates a magnetic field
electrostatic	:	The branch of physics that deals with the force exerted by a static (unchanging/moving) electric field on other charged objects
elevation	:	The elevation angle is the angle that increases from the horizontal towards the sky so that the values range$0° - 90°$
FastField	:	The radiation component dominates the electric field
Flash	:	Lightning strike/flash
graupel	:	(Also called soft hail) refers to rainfall formed when drip water supercooled condenses on snow
Interferometry	:	A system that estimates or calculates the angular difference of the VHF electromagnetic field detected by a pair of antennas within a certain distance
IntraCloud	:	Lightning strikes that occur within clouds
leader	:	The heat generated by the plasma filaments is generated when many streamers join together in a small airspace
Lightning Location System	:	The system is designed to be able to determine the location or estimate of a lightning strike more accurately
Lightning Mapping	:	Lightning sambar map
Orthogonal Vertical Loops	:	Two vertical and orthogonal loops with planes oriented NS (north-south) and EW (east-west)

		were used to measure the magnetic field to obtain the direction.
Low Frequency	:	The frequency with a wavelength of 30 MHz - 300 MHz
Magnetic Direction Finder	:	One of the lightning location system methods has the basic principle of two vertical orthogonal loops arranged with the orientation of the North-South (NS) and East-West (EW) planes.
Magnetic Fields	:	The region around a magnetic material or a moving electric charge within which the force of magnetism acts
Matlab	:	Programming platform designed specifically for engineers and scientists to analyze and design systems and products that transform our world
Meteorology	:	The science that studies the Earth and its symptoms, which are related to the Earth's components in the form of gas or commonly called air
Tri-Polar Charge	:	Type of charge on the cloud
NI Multisim	:	Programarrestand electronic schematic simulations of which it is a partSuitecircuit design program.
noise	:	General term for unwanted (and, in general, unknown) modifications that signals may suffer during capture, storage, transmission, processing, or conversion
Overlap	:	Shift in the windowing process in Matlab
Phase Fittings	:	One of the computational techniques in the Interferometry method in which the phase

		pairing is carried out according to the linear pattern of the difference in phase versus frequency
Picoscope	:	The perfect PC Oscilloscope for measuring and testing virtually all of the electronic components and circuits in any modern vehicle
Sliding Window	:	One type of method for doing windowing in Matlab
Streamers	:	The cold plasma that occurs whenever the electric field exceeds the air-permeable field
Time Delays	:	Differences in signal capture time on Interferometry antennas
Time Difference	:	Differences in signal capture time on Interferometry antennas
Time of Arrival	:	A method in Lightning Location System that uses the incident time of a specific feature of the electromagnetic waveform of lightning analyzed simultaneously at multiple sensors.
Very High Frequency	:	The frequency with a wavelength of 30 MHz - 300 MHz
Very Low Frequency	:	The frequency with a wavelength of 3 - 30 kHz
WindowSize	:	The size of the data division window/box in Matlab for the Interferometry method
windowing	:	The process of dividing wave data in Matlab for the Interferometry method into boxes of a specific size

NOMENCLATURE

α	:	Alpha
β	:	Betas
$\boldsymbol{\tau_d}$	:	Time Delays
$\Delta_{\boldsymbol{\theta}}$	:	Angle Change
BFB	:	Bolts From The Blue
BMKG:		Badan Meteorologi, Klimatologi dan Geofiska
c	:	Speed of light
cg	:	Cloud to Ground
d	:	baseline
DC	:	Direct current
DITF	:	Digital Interferometry
PRAYER		Directions of Arrival
	:	
EW	:	East-West
IC	:	IntraCloud
ITF	:	Interferometry
kHz	:	Kilo Hertz
LF	:	Low Frequency
LLS	:	Lightning Location System
MDF	:	Magnetic Direction Finder
MHz	:	Mega Hertz
MUSIC:		Multiple Signal Classification
$\boldsymbol{m/s}$	:	meters/second

ns	:	Nanosecond
NS	:	North-South
TOA	:	Time of Arrival
UWB	:	Ultrawideband
V	:	Voltage
VHF	:	Very High Frequency
VLF	:	Very Low Frequency
V/m	:	Volts/meters
x	:	Cartesian field x
y	:	Cartesian y field

CHAPTER I

INTRODUCTION

1.1 Background

Indonesia has a tropical climate and relatively high annual rainfall. This circumstance raises the water content of the cloud, increasing one of the probable natural events, lightning strikes [1]. According to data from the Meteorology, Climatology, and Geifiska (BMKG), in December 2022, more than 50% of Indonesia's territory experienced the intensity of cloud-to-ground (CG) lightning strikes, which were more than 60,000 times, particularly in the areas of Southern Sumatra, Kalimantan, Java, and Sulawesi [2].

Lightning is a rather common natural occurrence. Because lightning strikes generate vast and robust energy, they have a considerable impact on some objects they strike, and most objects struck by lightning will suffer severe damage. Furthermore, lightning is a natural occurrence that is impossible to anticipate and know when and where it will occur. As a result, the losses caused by lightning strikes are extremely hazardous to human life [3].

Lightning happens due to the release of positive and negative electric charges that occur and are present in clouds. *Cumulonimbus clouds* are clouds that can create lightning strikes. This type of cloud arises swiftly due to a relatively fast heating process on the Earth's surface that drives the existing water vapor to rise rapidly. As a result, one of the most distinguishing features of this cloud is its bumpy appearance. Lightning is caused by electrical discharge conditions caused by storms or thunder. It was followed by light and electromagnetic radiation, both of which had an effect. When this condition exists, the negative charge moves from

the cloud to the Earth, whereas the positive charge moves from the Earth to the cloud [4].

Lightning strikes are classified into three types based on current research: lightning strikes within one cloud, lightning strikes from cloud to cloud, and lightning strikes from cloud to Earth. These procedures begin with the initial discharge and are followed by a lightning strike. A lightning strike from cloud to ground is a lightning strike situation that is extremely dangerous to people because of its capacity to strike specific items and harm numerous things on the Earth's surface. Humans and other living things are in danger due to this lightning strike. Furthermore, this form of lightning strike is hazardous to the electrical distribution system since it can strike and destroy the power network, disrupting numerous human activities [5].

1.2 Problem Statement

Because lightning strikes pose major risks and costs, lightning strike research is essential for anticipating harmful consequences and facilitating the necessary recovery from lightning strikes. As a result, in this study, the Lightning Location System (LLS) will be studied using the Interferometry method to identify the location of lightning strikes more effectively, hence assisting in the lightning strike management process. In this study, a lightning location system program will be created with Matlab software using a sliding window with a window size of 128 and an overlap of 16, and a cross corelation will also be performed between signal data on each antenna to produce an accurate time difference value between antennas at the data collection station.

1.3 Objectives

The objectives of this study are:

1. To develop a lightning location system with Matlab software by applying windowing and cross-correlation.
2. To develop a lightning location map via azimuth and elevation angle values.
3. To simulate the Matlab program developed for the two previous objectives using sample data from Universiti Teknikal Malaysia Melaka (UTeM) interferometry station.

1.4 Scope of Work

The scope of this research is as follows:

1. Developing algorithms for lightning location systems using Matlab software.
2. Developing a Matlab program with a window size of 128, overlap of 16 and performing cross-correlation for the signal data of antennas A and B and antennas B and D.
3. Simulating the program developed with sample data from the UTeM interferometry station.
4. Developing a lightning location map via azimuth and elevation angle values.

1.5 Hipotesis

This research method provides for the comprehensive and accurate monitoring of the locations of lightning strikes. Implementing window size and overlap with a smaller size can more clearly display the observed lightning movement, allowing for improved comprehension of the specifics of the lightning movement during the hitting process. This study also demonstrates that the interferometry approach may create lightning location maps.

1.6 Thesis Structure

The structure in the authorship of this proposal is as follows:

CHAPTER I INTRODUCTION

This chapter discusses the research background, problem statement, objectives, scope of work, and thesis structure.

CHAPTER II LITERATURE REVIEW

This chapter discusses the basic theory of lightning strikes, location systems, and interferometry methods.

CHAPTER III RESEARCH METHODOLOGY

This chapter contains the place, time, equipment used, series of experiments, testing procedures, data collection techniques and data processing used in the preparation of the final project and explains, in general, the research process to be carried out.

CHAPTER IV RESULTS AND DISCUSSION

This chapter describes the results of the data that have been identified and analyzed, as well as the discussion.

CHAPTER V CONCLUSIONS AND RECOMMENDATIONS

This chapter is a conclusion from the results of the research presented in CHAPTER IV and suggestions related to the research that has been done.

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APPENDICES

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