UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF LIGHTNING DETECTION SYSTEM USING THE COMBINATION OF THE ELECTRIC FIELD AND MAGNETIC 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

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APPROVAL

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ABSTRAK

Kilat adalah pelepasan elektrik yang biasanya berlaku sebagai kerosakan elektrik di udara apabila dua kawasan caj elektrik (caj positif dan kawasan caj negatif) di atmosfer atau di atas tanah sementara menyamakan diri mereka. Sistem Pengesanan Kilat (LDS) dan sistem pemetaan telah menunjukkan bahawa sistem ini boleh digunakan untuk meminimumkan kesan berbahaya petir dengan menyediakan amaran awal bahaya seperti itu. Penyiasat petir telah mempromosikan LDS berdasarkan teknik Time-of-arrival yang menggunakan medan elektrik dan pengukuran medan magnet dari multi-stesen yang mampu menentukan lokasi dan pemetaan lokasi kilat. Utama utama komponen LDS ialah Litar Bersepadu (IC) yang dipamerkan sebagai pengikut voltan (penampan). Masalah utama LDS yang ada di pasaran adalah mengenai ketidakpastian ciri yang direkodkan oleh sistem. Sistem ini hanya muncul sebagai nilai pengukuran atau parameter tanpa mengetahui butir-butir ciri-ciri pelepasan kilat. Di samping itu, pengeluar instrumen LDS tidak akan mendedahkan operasi sebenar sistem kerana ia adalah perkara sulit. Selain itu, IC yang telah digunakan oleh banyak penyelidik kilat adalah mahal dan beberapa cara tidak mudah didapati di pasaran. Oleh itu, projek ini telah diperkenalkan khas untuk menentukan kemungkinan IC sedia ada dan lebih murah di pasaran untuk digunakan untuk sensor kilat pada masa akan datang. Projek ini memperkenalkan dua jenis IC untuk medan elektrik dan empat jenis IC untuk menentukan pengesan medan magnet. IC khusus untuk litar medan elektrik adalah THS 4631 (Texas Instrument) dan LMH 6559 (National Semiconductor). Di sisi lain, IC untuk menentukan pengesan medan magnet ialah LMH 6639, LMH 6643, LMH 6645 dan LMH 6655 (semua dari Semikonduktor Negara).

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OrCAD 9.2 telah digunakan dalam projek ini untuk menentukan bandwidth terbaik untuk setiap sensor khusus untuk sensor medan magnet dan elektrik. Kaedah Cuba dan Ralat digunakan untuk menentukan IC terbaik berdasarkan hasil jalur lebar yang diperhatikan melalui perisian OrCAD. IC yang dipilih kemudiannya merapatkan kepada konfigurasi litar yang sesuai dan digunakan untuk proses pengukuran sebenar. IC yang dipilih ialah THS 4631 untuk medan elektrik manakala LMH 6639 untuk medan magnet kerana ia dapat menangkap gelombang kilat yang diinginkan dan ia juga telah diuji di makmal. Penglibatan utama untuk projek ini adalah bunyi bising yang dihasilkan dari penukar yang digunakan untuk memecahkan bekalan tunggal kepada bekalan dua. Isyarat bunyi adalah bertindih dengan isyarat kilat dan ia juga boleh mencetuskan oscilloscope untuk menangkap isyarat yang tidak diperlukan untuk pengumpulan data. Selain itu, bekalan sensor juga merupakan salah satu masalah utama kerana sensor boleh dimatikan semasa ia diperlukan untuk menangkap isyarat. Untuk projek ini, bekalan sistem penyejukan dan sistem sensor dikongsi. Penggunaan sistem penyejukan bergantung kepada suhu sekitar dan jika suhu yang tinggi, bekalan tidak dapat menampung LDS hingga malam menjelang. Oleh itu, terdapat penyelesaian tertentu yang disyorkan untuk kerja masa hadapan ialah sensor LDS perlu menggunakan bekalan daripada dua bateri, mengasingkan bekalan sensor dari bekalan lain dan menyediakan bateri jangka hayat panjang untuk LDS.

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ABSTRACT

Lightning is electrical discharge typically occurs as electrical breakdown in air when two electrically charge regions (positive charge and negative charge regions) in the atmosphere or on the ground temporarily equalize themselves. Lightning Detection System (LDS) and mapping system has shown that the system can be used to minimize the harmful effect of lightning by providing early warnings of such hazards. Lightning investigators have promoted that the LDS based on Time-of-arrival technique which applying the electric field and magnetic field measurement from multi-stations capable for determining location and mapping lightning location. The main important of LDS component is the Integrated Circuit (IC) which exhibit as voltage follower (buffer). The main problem off available LDS in the market is regarding on the uncertainty of the feature being recorded by the system. The system only appears as a measurement value or parameters without knowing the details of the characteristics of the lightning discharge. In addition, the producer of the LDS instruments will not expose the real operation of the system because it was a confidential matter. Furthermore, the ICs that have been used by many of lightning investigators were expensive and some way not easily available in the market. Therefore, this project has been introduced specially to determine the possibility of available ICs and cheaper in the market to be used for lightning sensors in the future. This project introduces two type of ICs for the electric field and four type of ICs for determining magnetic field detector. The specific ICs for electric field circuit were THS 4631 (Texas Instrument) and LMH 6559 (National Semiconductor). On the other hands, the ICs for determining of magnetic field detector are LMH 6639, LMH 6643, LMH 6645

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and LMH 6655 (all from National Semiconductor). OrCAD 9.2 was used in this project to determine the best bandwidth for each sensor specifically for electric and magnetic field sensor. Try and Error method was used to the determined the best ICs based on the bandwidth produce that observed via OrCAD software. The chosen IC then was etching to a suitable circuit configuration and applied to the real measurement process. The chosen ICs was THS 4631 for electric field while LMH 6639 for magnetic field because it could capture the desire lightning strike wave and it also have been tested in laboratory. The main distraction for this project was the noise that produce from the converter that used to split the single supply to dual supply. The noise signal was overlap with the lightning signal and it also could trigger the oscilloscope to capture the signal which unnecessary for the data collection. Other than that, the sensor supply also is one of the major problems because the sensor could turn off while it needed to capture the signal. For this project, the supply of the cooling system and the sensor system was shared. The cooling system usage was depending of the surrounding temperature and if the temperature as high, the supply could not cope the LDS until night coming. Therefore, there were certain solution that recommended for future work which are the LDS need to used dual supply for the battery, isolate the sensor supply from other supply and provide a long-life span battery for the LDS.

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DEDICATION

To my beloved father, mother, families, lecturers and friends. Thanks for everything.

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LIST OF SYMBOLS

A	-	Ampere
dB	-	Decibel
Hz	-	Hertz
k	-	kilo
M	-	Mega
V	-	Volt
G	-	Giga

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LIST OF ABBREVIATIONS

BNC	Bayonett Neill Concelman
PCB	Printed Circuit Board
UTeM	Universiti Teknikal Malaysia Melaka
LDS	Lightning Detection System
IC	Integrated Circuit
LDS	Lightning Detection System

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter consists of the project background, problem statement, objective, scope, significant of the project and the description of the project. Generally, this project highlighted the background of Integrated Circuit (IC) that have been used as voltage follower (buffer) for detection electric field and magnetic field generated by the lightning flashed. Next, this chapter introduce three objectives for determining suitable ICs to be used as electric field and magnetic field detectors, scope or the flows and limitation of the project, significant of the project for Malaysian Society and some brief explanation of overall project.

1.2 Project Background

Lightning is a natural phenomenon that fascinate some people but some of them lighting is might be the dark incident for them. It such a luminous phenomenon that cause in the short duration and it is so dangerous because lightning carried high voltage and current. Lightning happen due to the imbalances charge between storm clouds and the ground, or within the clouds themselves. It exists by discharging between the positive and negative charge in the storm cloud that be polarized. The lightning of flash strike everywhere that could make it neutralize it charge and this lightning strike produce the

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electric and magnetic fields or also known as the electromagnetic field. These magnetic field and electric field is perpendicular to each other. Only the specific detector could detect the lightning strike electromagnetic field dur to it have a special frequency in range of Hz to MHz. The detector only captures the induced electromagnetic field that produce by the lightning strike and this detector construction is using the certain electronic component that could fit to the lightning frequency. There are two components in the electromagnetic wave which are electric field and magnetic field. Deeply inside electric field detector, it could be divided by two which are slow field and fast field detector while magnetic field detector only one. This project focuses on the development of the electric field (fast field) and magnetic field. This mean, the electric field sensor could only detect the radiation that produce by the lightning. The purpose of the slow field sensor is to detect the preliminary breakdown or clearly as the process before the strike occur. Therefore, the fast field detector used the bandpass filter (voltage follower) as a configuration while magnetic field used low pass filter (integrator) as a configuration. The reason why the electric field and magnetic field used different configuration because of the circuit itself determined the mathematical expression that used to display the voltage produce by lightning. If not, the manual calculation needs to be performed in order to analyse the signal.

1.3 Problem Statement

Previous studies have proven that the LDS based on Time-of-arrival technique that used a combination of electric field and magnetic field measurement from multi-stations can provided agreement for determining location and mapping lightning location. The heart

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