SHORT RANGE PHASED ARRAY RADAR SYSTEM FOR LIGHTNING REMOTE SENSING APPLICATION

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DEDICATION

This project and research work is dedicated to my beloved parents for their devoted care throughout my life, my loving siblings and my friends for their encouragement and love.

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ABSTRACT

This final year project traverses the Short Range Phased Array Radar System for lightning remote sensing application. Short range phased array radar project is a research project that carries the potential to deliver lightning based analytical studies in future. In this project, it compromises of design, simulation, fabrication and analysis of linear tapered slot antenna (LTNA). The antenna design and simulation covers the parametric analysis done on the different geometries of the antenna with the aid of CST software. Based on the parametric analysis, an optimized linear tapered antenna was designed and the finalized antenna was manifested physically through the fabrication process. FR4 board was used to fabricate the antenna. There are chosen imperative elements that are analyzed to determine the performance of the antenna such as s parameter, radiation pattern, gain and directivity. Both the simulation and measurement result were obtained and compared, to determine the performance of the antenna at the designated frequency 2.4GHz. The return loss, gain, directivity and bandwidth of the antenna at the operating frequency are < -10dB, 6.127dB, 10.007dB, 180 MHz respectively. Finally, the antenna was successfully incorporated with the IEE80.1b device.

ABSTRAK

Projek tahun akhir ini bertujuan untuk membina sistem radar pelabagai peringkat yang boleh beroperasi dalam jangka jarak dekat bagi aplikasi lightning remote sensing. Projek radar pelbagai peringkat ini merupakan satu projek penyelidikan yang mempunyai potensi untuk menyampaikan kajian analisis berdasarkan kilat dalam masa akana datang. Projek ini, mengkompromi reka bentuk, simulasi dan analisis linear antena slot tirus (LTNA). Terdapat unsur-unsur penting yang dianalisis untuk menentukan prestasi antena seperti s-parameter, directivity, corak sinaran, keuntungan dan saham. Kedua-dua keputusan simulasi dan pengukuran telah diperolehi dan dibandingkan, untuk menentukan prestasi antena pada 2.4GHz frekuensi yang ditetapkan. *Return loss* kurang daripada -10dB. Dari segi *gain, bandwidh* dan *directivity,* masing masing memperoleh sebanyak 6.127dB, 10.007dB dan 180 MHz. Keputusan telah dianalisis dan konklusi terhadap prestasi dan penggunaan antena yang dinyatakan dalam lapaoran akhir tahun ini.

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LIST OF ABREVIATIONS

WLAN – Wireless Local Area Network

UTeM – Universiti Teknikal Melaka Malaysia

IEEE - The Institute of Electrical and Electronic Engineers

FYP – Final Year Project

LTSA – Linear Tapered Slot Antenna

TSA - Tapered Slot Antenna

FR – Flame Retardant

HPBW – Half Power Bandwiidth

FNBW – Full Null Beamwidth

WIFI – Wireless Fidelity

CHAPTER 1

INTRODUCTION

Chapter one focuses on the project's overview, project's objective and problem statement, scope of work, methodology, and thesis structure. It will explain the basics of the project that is about the development of radar system and the front end system of short range phased array radar and the Linear Tapered Slot Antenna. These will be explained in this chapter to give guidance to what the project is about.

1.1 Overview of the Project

The project is basically a research based project, in which the short term goal has been set to develop a short range phased array radar system. Radar is a detection system that relies on the usage of radio waves to determine the distance, velocity and angle of object. A basic radar system consists several subsystems which compromises of a transmitter antenna, an emitting antenna, a transmitter, a receiver and a processor. According to Gregory L. Chavart [1], the author of Small and Short Range Radar System, phase array radar has been very expensive and conventionally used in air defense system. At MIT Lincoln Laboratory, along with John Peabody and Tyler Ralston, Gregory L.Chavart successfully built a high performance through-wall imaging system using Wi-Fi antennas and pegboard. This has been taken as an inspiration or basis, to create low cost phased array radar that could operate at short range.

In recent years, there has been an increase of popularity to operate radar system at Wi-Fi frequencies. Numerous device operating at 2.4GHz band that complies with Bluetooth, Home RF and IEE 802.11b are widely available in market now. IEEE 802.11b refers to the Wi-Fi adapters that incorporated with commercial pc's to read Wi-Fi signal. Since, this devices are low in cost, an antenna will be developed to be integrated with the IEE802.11b devices. With that the radio frequency could be interfaced with any computer and therefore enabling the development of radar signal analyzing algorithms by using software such as MATLAB or LabVIEW. One such algorithm is the SAR algorithm. Synthetic Aperture Radar (SAR) is a modern ground mapping technique where high resolution is achieved by a very large aperture that is synthesized over the flight path of an aircraft. This is done by recording reflected radar pulses at known locations along the flight path. The radar must accurately know the aircraft's position and back-out perturbations in flight path so that all scattered pulses are aligned in time and phase. After that the SAR imaging algorithm is applied to the data to process an image

The antenna is developed to map the reflectivity values of cloud particles. As mentioned before, the project is a research based project thus the long term objective is to

study the scattering particles of clouds and analyzing them. Cloud particles can be divided into three types which are water droplets, supercool water droplets and ice crystal which are located in the intermediate layer of cloud , lower layer of cloud and top of thundercloud respectively. The study an analysis on the cloud particles could lead to the harnessing energy from lightning. Harvesting energy from lightning has been taken up as a solution to depleting unrenewable source by many advanced countries and the race to develop the technology in harvesting the lightning energy among the scientist and engineers is ongoing. However, there are no established and mature studies on this technology and the scientific literature can hardly be found, therefore this project is carried out to be as a sensible part of the research studies [2][3]. Therefore as a stepping stone, the project is initialized with the development of the antenna that could accommodate the radar application. Thus this project will be focusing on the design and development of Linear Tapered Slot Antenna (LTSA) antenna that is capable to operate at 2.4GHz.

1.2 Objective of the project

The objective of the project is to design, simulate, fabricate and measure Linear Tapered Slot Antenna (LTSA) which can function as a radar antenna. The required frequency is 2.4GHz with an operating bandwidth of 200MHz.

1.3 Problem statement

This problem that will be apprehended in this project is the high cost of the radar system and also the accountability of the radar antenna to function at 2.4GHz. Since, the antenna will be implemented in capturing the scattering particles of cloud, an antenna with an aperture is required. A solution is seek by developing a printed Linear Tapered Slot Antenna that could operate at higher frequencies.

1.4 Scope of project

The scope of the project is to design LTNA antenna that could operate in S-Band region particularly at 2.4GHz. The antenna will be simulated in the CST Microwave studio and fabricated on a negative FR4 board. The simulation results of the antenna in terms of return loss, radiation pattern and gain will be analyzed.

1.5 Project outcome

It is expected that by the end of this project, an LTNA antenna could be developed to accommodate radar application by operating at the consent of IEEE 802.11b standard. The development of this antenna is expected to yield out result within the considerable level of each parameter evaluated.

1.6 Methodology

This project was initialized with the gathering ofinformation related to Linear Tapered Slot Antenna. The sources and information are obtained through journals, reference books, E-books and also the Internet. The information collected are about the the design process of Linear Taperd Slot Antenna acoording to the respected mode of application. This was then followed by emulating those design process to design a LTSA antenna that is capable of operating at 2.4GHz. Subsequently, parametric study is done to analyze the influence of antenna geometry on the performance of the antenna eventually leading to the optimization of the antenna performance. Finally, the optimized antenna is fabricated and the antenna paramaters are analyzed in this report.

CHAPTER 2

LITERATURE REVIEW

In this project, many journals, books, articles and internet resources are studied thoroughly. By research, many new methods, ideas, facts, have been gathered and documented which are very helpful in completion and success of this project.

2.1 Introduction

Antennas are key components of any radar system. A radar antenna is a device that can act as a transmitter or as a receiving device that receives reflected or echo signal and delivers it to the receiver. To be precise, the term antenna is defined as means for radiating or receiving radio waves in free space as per the IEEE Standards of Terms for Antennas [4][5][6]. Basic antenna parameters comprises of return loss, gain, Half-Power Bandwidth (HPBW), First-null Beamwidth (FNBW), directivity, radiation pattern and efficiency. There are many different type of antennas with their respective performance value, however these are the parameters that will characterize the type of antenna and the performance of the antenna based on the application it is being implemented.

As mentioned before, there are many types of antenna and it can be grouped into two main domains which are micro-strip and planar. In these domains, a lot antennas have been invented for different applications such as WLAN, WIMAX, Radio Frequency ID and Radar. Radar system which was one owned by only military forces have now been commercialized until to the extent of home security application. This advancement caused an explosive growth in antenna design needs. Figure 2.1 illustrates the general category and types of antenna.

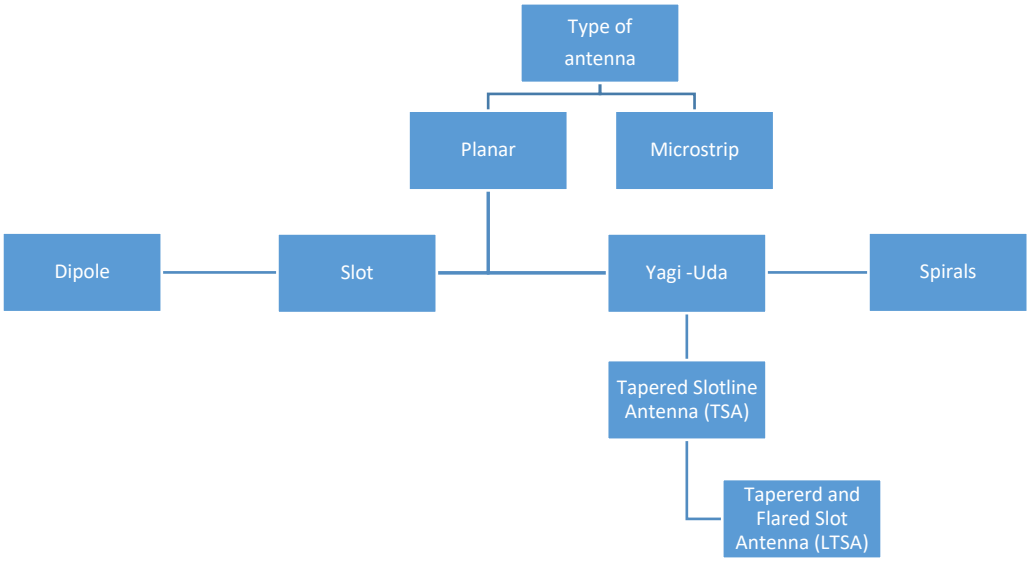

Figure 2.1: General category and types of antenna.

2.2 Basic antenna parameters

2.2.1 Radiation pattern

Generally, the radiation of antenna is caused by moving electrons. Acceleration and deceleration of charges within the antenna produces different radiation pattern depending on the antenna structure. An antenna radiation can be also defined as a mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates [6][7]. The representational of the radiation properties of the radio wave conducting device as a capacity for precise position might make as far as energy pattern and also amplitude field pattern [6].