UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF A PLANAR LOG PERIODIC SPIRAL ANTENNA FOR ENERGY HARVESTING

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

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Tajuk: Design of a Planar Log Periodic Spiral Antenna for Energy Harvesting

Sesi Pengajian: 2020

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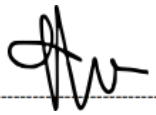

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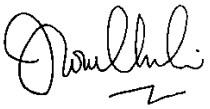

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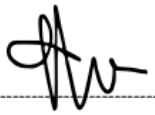
Signature: 

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology (FTKEE) of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

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Co-supervisor: DR. A K M ZAKIR HOSSAIN

ABSTRAK

Kertas kerja ini menghuraikan tentang proses penuaian tenaga frekuensi radio dengan menggunakan antena jenis satah lingkaran logaritma. Julat operasi bagi antena ini adalah diantara 300MHz sehingga 3GHz . Antena ini direka dan disimulasikan beberapa kali dengan menggunakan perisian CST Studio Suite 2019. Nilai impedan yang digunakan untuk simulasi antena ini adalah 80Ω. Kebiasaannya, antena jenis ini menghadapi masalah untuk mencapai potongan frekuensi yang rendah. Oleh itu, rekabentuk baru diperlukan untuk mengatasi permasalahan ini. Parameter baru diperlukan untuk mencapai potongan frekuensi yang rendah dengan menggunakan formulasi tertentu. Pencapaian antena ini direkodkan dengan menggunakan simulasi perisian CST dalam aspek Pulangan Hilang(S11), Ratio Gelombang Voltan Sendirian (VSWR) , Medan Elektrik (E-Field) , Medan Magnetik (H-field), Permukaan Elektrik , Aliran Kuasa , Kecekapan Sinaran, Kearahan, Kedapatan dan Polarisasi .

ABSTRACT

This paper describes radio frequency energy harvesting using Planar Log Spiral antenna. The operating range is between 300MHz to 3GHz frequencies. The antenna was designed and simulated multiple times by using the CST Studio Suite 2019. The simulated input impedance for log spiral antenna is 80Ω. Usually, the log spiral antenna has difficulty to achieve lower cutoff frequencies. Therefore, a new design is needed to overcome this problem. By using several formulas and calculations, a new parameter is used to design a new planar log spiral antenna that can achieve lower cut-off frequency. The behaviour of the proposed antenna is predicted by running CST software simulation in terms of Return Loss (S11), Voltage Standing Wave Ratio (VSWR), Electric Field (E-Field), Magnetic Field (H-field), Surface Current, Power Flow, Radiation Efficiency, Directivity, Gain and Polarization.

DEDICATION

I dedicate this project report to my beloved parents, my supervisor, co-supervisor and my BEET course mate. A special thanks to my father, Encik Wan Mohamed Bin Wan Ibrahim and my mother, Puan Naimah Binti Jaafar who always give me courage and support to do this project. Furthermore, I would like to say thank you to my supervisor, Encik Nurulhalim Bin Hassim for his guidance, advices, encouragement, inspiration and attention given throughout the development of this project. Lastly, I would like to say thank you to my BEET course mates that always support me to develop and complete this project.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter introduces a brief idea of the project. It focused on the overview of the project, detailing the objectives, the problem statement, scope and outcome of the project.

1.1 Project Background

The energy from the environment such as electromagnetic radio frequency (RF) could be harvested into power system for low and ultra-low power electronics devices. Therefore, Energy Harvesting System (EHS) currently become a promising technology to be used for charging battery for low and ultra-low power electronic devices. In EHS, the energy collected from the surrounding environment sources can be converted into two types of Storage. The first is Harvest-store-use(HSU) where a battery storest the harvested energy for future use. The second is harvest-use(HU) where harvested energy is directly being used by the end device. With this in mind, a new design of planar log periodic spiral antenna is needed to maximize the collective of surrounding energy from environment sources such as wireless radio transmission and TV broadcasting. Figure 1.1 show how the typical block diagram of RF energy harvesting circuit usually looks like.

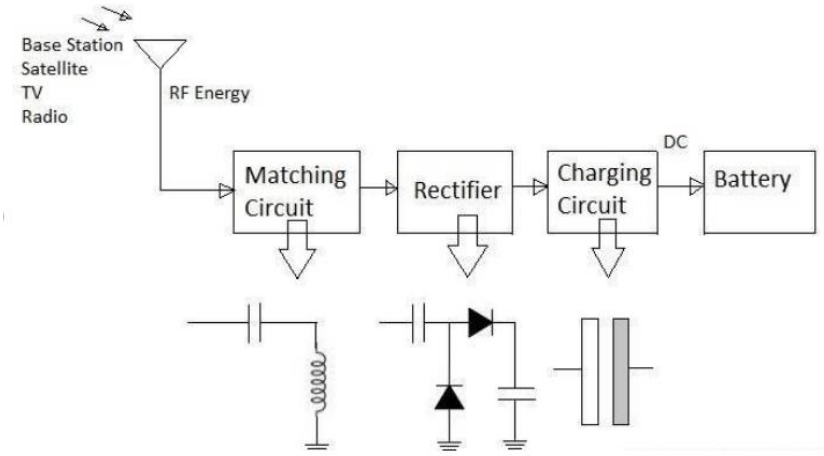

Figure 1.1: Typical Block Diagram of RF Energy Harvesting Circuit

1.2 Problem Statement

Most of the previous designed Planar Log Spiral antennas can provide good bandwidth at high frequency. However, the same cannot be said for lower cut-off frequencies range such as from 300MHz to 3GHz. Furthermore, there is another limitation for Planar Log Spiral antenna in extracting the RF energy from the environment into battery or directly into DC devices. The capability of the antenna is limited in terms of sensitivity as the antenna operates at wider bandwidth.

1.3 Objectives

The objective for this study is to design and fabricate a planar log spiral antenna for RF energy harvesting that achieves low cut-off frequency range between 300MHz to 3GHz. The optimization of this antenna design will be done by simulation using CST

Studio Suite 2019. The final stage is to fabricate the planar log spiral antenna on FR4 PCB.

1.4 Scope of research

As for the scope, this study will include understanding how log spiral antenna acts as receiver antenna. In addition, the study will also discover how an Ultra High Frequency (UHF) application work within the frequency band of 300MHz to 3GHz. Furthermore, this study will also uncover the steps on how to design and simulate a planar log spiral antenna for energy harvesting using CST Studio Suite 2019 to get the desired results. Lastly, the selection of materials will be done before the actual antenna fabrication.

1.5 Organization

This report have five chapters which are introduction, literature review, methodology, result and discussion and conclusion and recommendation. Each of the chapter will discuss in more detail about the study.

1.6 Thesis Organization

For chapter 1, it is about the introduction of the project. In this chapter, it consists of project background, problem statements, objectives and scope of research. All of the summary information that are related to this project will be discussed and presented in this chapter.

For Chapter 2, it is about previous studies that are related to this project. It is also known as literature review. In this chapter, there are discussions about the approaches and

methods being used by other researchers in their study. This is important data to be used in analysing and comparing the features of the previous studies that could be used as guideline for this project.

For Chapter 3, it is focused on the methodology and approaches to the related project. This will include flowchart of the projects, the software and hardware to be used in this project. At the same time, it also about how the process work, how to develop and implement the project successfully.

For Chapter 4, it will present about the results and discussion of the project. The result of the design and simulation for the antenna is shown by running a simulation using CST Studio Suite 2019 software before fabricate the antenna into PCB. The result of the antenna's functionality is recorded and shown in this chapter.

For Chapter 5, which is conclusion and recommendation. It will present about the summary of the project. It also will present a suggestion and recommendation that can be used to improve and overcome the problem of the newly designed antenna in the future.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Each of the antenna have their own advantage and disadvantage on receiving radio frequency signal for energy harvesting. However, this project will focus on bi-directional antenna or Planar Log Periodic Spiral antenna specifically. At the same time, this chapter will also summarize the previous studies in designing and developing antenna with different specifications such as gain, directivity, pattern and others.

2.1 Log Periodic Spiral Antenna

Like others, Log-Periodic Spiral Antenna is a device made of conductive metal that acts as interface for electromagnetic radio waves to pass through space and electric current in metal conductors either for transmitting or receiving radio waves. It has two arms that are connected in the middle with each arm showing a spiral shape. The direction of radio waves transmitting and receiving is determined by its directivity which is broadside of the antenna plane. Meanwhile, the range of radio waves that can be transmitted and received by this antenna is unlimited. This is so, because it belongs to the frequency independent antenna class which can operate in a wide range of frequencies. The performance of this antenna depends on its characteristics such as the number of turns, inner radius, outer radius, spacing between the turns, pattern and others aspect. Therefore, antenna design is very important process to create a suitable antenna for energy harvesting at specific radio wave frequency range which is from 300MHz to 3GHz for this project. Lastly, the polarization and radiation pattern remains unchanged over large frequency region for this type of antenna.

Figure 2.1: Top and bottom view of log spiral antenna

Figure 2.1 shown an example of log spiral antenna with a balun

2.2 Previous related research

According to research paper studied by (N.Eltresy *el al*., 2018), it is stated that log spiral antenna structure have two identical arms where the shape of each spiral arm is obtained from an exponential curves. This antenna has the advantages of easily achieving wide bandwidth, circular polarization, high directivity and impedance matching.

To design a log spiral antenna, the author used the following equations to calculate the inner and outer radius of the spiral.

For inner radius, r1;

$$r1 = k\, e^{\alpha\varphi}$$

For outer radius, r2;

$$r2 = k\, e^{\alpha(\varphi-\delta)}$$