DESIGN OF DUAL-BAND MICROSTRIP ANTENNA WITH AIR GAP FOR ENERGY TRANSFER

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

To my beloved mother and father

ABSTRACT

In this century's where the country is preparing for IR 4.0, the revolution of technology has made devices like mobile phone, tablets, laptops, portable devices important in our life. These devices transfer lots of data by using electromagnetic wave to keep up with the technologies. The use of green technology such as RF energy harvesting help in overcoming the problem as the advanced wireless broadcasting and communication system that generated the availability of free energy. However, it also has limitation which is the amount of captured energy of RF source is low. A dual-band operation is adapted on the antenna which can increase gain thus increase the amount of captured RF source. This project proposed on the design of dual-band antenna for energy transfer application with the main objective to design and develop a dual-band antenna that possess dual-band characteristics with improved antenna gain and directivity with the addition of air gap on microstrip antenna design. The development of this project involves the scopes of designing and testing of antenna by using CST software and VNA equipment. In designing process, fundamental parameter of antenna that can improve the performance were analysed and validated. The proposed dual-band antenna can achieve 44.707 dB and 32.163 dB of return loss, and gain of 6.31 dB and 7.82 dB respectively. The antenna has advantage of low cost and high gain for dual band operating frequency.

ABSTRAK

Pada abad ini di mana negara sedang membuat persiapan untuk menuju Revolusi Industri 4.0, kemajuan teknologi dalam membuat peranti seperti telefon bimbit, tablet, komputer riba, peranti mudah alih menjadi penting dalam kehidupan kita. Alat-alat ini memindahkan banyak data dengan menggunakan gelombang elektromagnet untuk berada sejajar dengan teknologi masa kini. Penggunaan teknologi hijau seperti RF penuaian tenaga membantu dalam mengatasi masalah ini kerana kecanggihan sistem penyiaran dan komunikasi tanpa wayar dengan menggunakan tenaga bebas. Walau bagaimanapun, ia juga mempunyai had disebabkan oleh jumlah tenaga yang ditangkap daripada sumber RF adalah rendah. Operasi dua jalur diimplimentasikan pada antena bagi meningkatkan 'gain' seterusnya meningkatkan jumlah sumber RF yang ditangkap. Projek ini mencadangkan reka bentuk dan pembangunan antena dengan operasi dua jalur untuk aplikasi pemindahan tenaga dengan objektif utama untuk mereka bentuk dan membangunkan antena yang mempunyai ciri-ciri dua jalur dengan 'gain' antena dan 'directivity' yang lebih baik dengan penambahan ruang udara kepada reka bentuk mikrostrip antena. Pembangunan projek ini melibatkan skop mereka bentuk dan ujian ke atas antena dengan menggunakan perisian CST dan peralatan VNA. Dalam proses mereka bentuk, ciri-ciri asas antena yang boleh meningkatkan prestasi dianalisis dan disahkan. Antena yang beroperasi pada dua jalur frekuensi yang dicadangkan boleh mencapai 6.31 dB dan 7.82 dB 'return loss' dan 'gain' sebanyak 6.31 dB dan 7.82 dB. Antena ini mempunyai kelebihan kerana kosnya sedikit dan 'gain' yang tinggi untuk dua frekuensi.

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LIST OF SYMBOLS AND ABBREVIATIONS

CST	:	Computer Simulation Technology
WPT	:	Wireless Power Transfer
VNA	:	Vector Network Analyzer
AUT	:	Antenna Under Test
RF	:	Radio Frequency
VSWR	:	Voltage Standing Wave Radio
CSSRR	:	Complementary Single Split Ring Resonator
SSR	:	Split Ring Resonator
dB	:	Decibels

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wireless Power Transfer (WPT) is an innovative technology that has permeated major areas in consumer and industrial electronic market. It also promises of freeing people from tyranny of power cords as it is the transmission of electrical energy without the aid of man-made conductors. There are various forms of WPT including solar energy, microwaves and magnetic energy. Microwave Power Transmission is one of the promising technologies and may be the righteous alternative for efficient power transmission. This wireless transmission is useful to power electrical devices in case where interconnecting wires are inconvenient, hazardous, or are not possible [1].

1.2 Microwave Power Transfer

Microwave Power Transfer is defined as the transfer of power through space by means of microwaves. In specific, MPT system converts direct current (DC) power to microwaves, transmits that microwave radiation to a target, and the target converts the microwave radiation back to DC power [2]. Figure 1.1 depicts a block diagram of the MPT system. First the microwaves are generated by the microwave generator. This radiation then passes through the Coax-Waveguide Adapted, which in turn passes through the waveguide circulator, a device that reduces the radiation to exposure from outside power. Finally, the radiation passes through the tuner and directional coupler device, which separates the signal according to signal propagation direction. The radiation is then transmitted over the air through antenna, where it is received by the antenna at the rectenna, at which the microwave radiation passes through a low pass filter, then a matching network, then a rectifier as it is converted to DC power.

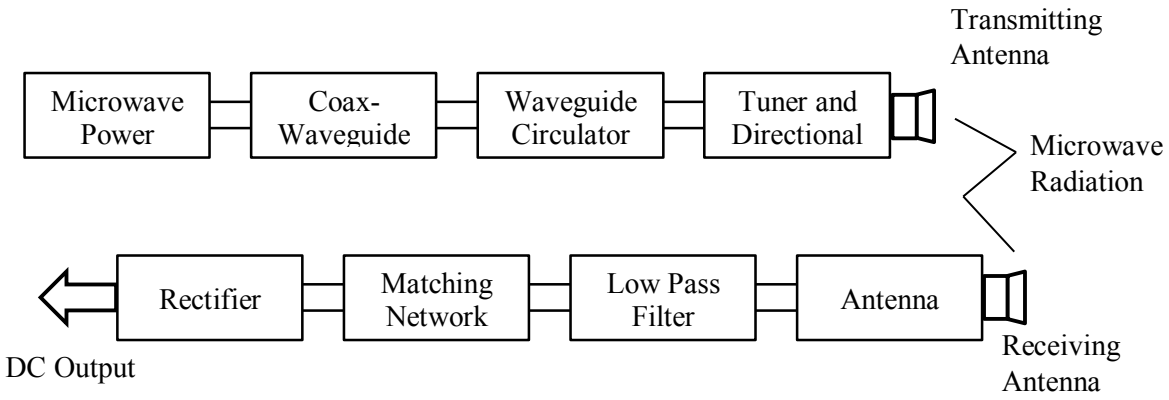

Figure 1.1: Block diagram of Microwave Power Transfer

1.3 Importance of Wireless Power Transfer

There is several importance of wireless power transfer such as wireless power transfer allows the technology to get rid of power pot. The technology can be advanced to product that is water-resistant as wireless power are widely used. Wireless power also means less cord clutter. Since each person had problem of having to change different charging cord for different device, WPT solve those problem by providing one universal, cordless power solution for all those devices. Major benefit of WPT is it increased product life by eliminating the physical limitation of connector as wireless power offer better design manufacturers.

1.4 Problem Statement

In this century's where the country is preparing for IR 4.0, the revolution of technology has made devices like mobile phone, tablets, laptops, portable devices important in our life. These devices transfer lots of data by using electromagnetic wave to keep up with the technologies.

New technologies are now working to portable technologies, which aiming on a stand-alone device that can be carried in one hand. Therefore, making the onboard power supply important. Battery is a more portable system that can reduce the hassle with wires. Modern days, electronic circuits are consuming less power, also these are improving day by day, which extends battery life in a significant way. However, battery has limited life span as it needed to be charge or replaced frequently. Moreover, the decomposition of battery is also not environmental friendly because of the heavy metals in battery. With that, the use of green technology such as RF energy harvesting

could help in overcoming the problem as the advanced wireless broadcasting and communication system that generated the availability of free energy.

Although the RF energy harvesting can be the solution, it also has limitation which is the amount of captured energy of RF source is low. Low level power may cause by the mismatch network on antenna. To achieve the amount of maximum transfer, receiving antenna must be designed by considering many factors which able to operate for the specific operating frequency and can reduce the transmission loss. Therefore, a high gain microstrip antenna with simple design and low cost were proposed.

1.5 Objectives of Research Work

The aim of this research work is to design dual-band microstrip antenna with an air gap. Specifically, the objective of this research is as below

- To design a dual-band antenna operates at 1.8 GHz (ISM Band) and 2.4GHz (GSM Band).
- To develop an antenna design that can achieve gain of more than 5dB.
- To evaluate, compare and analyze performance of designed dual-band antenna.

1.6 Scope of Work

This research work focuses on designing dual-band microstrip antenna with air gap. The scopes of work are as summarized below:

1. The dual-band microstrip antenna which operates at 1.8GHz of Global System for Mobile Band (GSM Band) and 2.4GHz of Industrial, Scientifical and Medical Band (ISM Band).
2. The antenna was designed using Computer Simulation Technology (CST2014) Studio Suite software.
3. Fabrication process of the proposed dual-band microstrip antenna was done to validate the simulation and measured result.

1.7 Thesis Organization

This thesis consists of five chapters. In Chapter 1, an introduction and basic concept on wireless power transfer, microwave power transfer, its importance, problem statement, objectives, scope of thesis are presented.

Chapter 2 presented a brief on the RF energy harvesting as the antenna application. Next, introduction of antenna and microstrip antenna was discussed. Basic antenna parameter such as return loss, bandwidth, gain, radiation pattern and efficiency are discussed. The literature review was conducted on journals and websites as sources to obtain information.

In Chapter 3, a flow chart that shows the process of the project is presented. The design procedural of antenna started from literature review until the fabrication and

measurement process. The specification and parameter of proposed antenna were specified.

Chapter 4 presented the detailed proposed antenna design including the antenna dimension. The result of simulation from CST software were optimized and compared with the measurement in term of return loss, radiation pattern and gain. Analysis of parametric optimization is conducted to achieve better performance of antenna by varying the size slot and position slot.

Chapter 5 concludes on the overall of project. A conclusion on designed dual-band microstrip antenna at 1.8 GHz and 2.4 GHz for energy transfer was made. Some suggestion and recommendation on improvement of antenna performance are presented.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will explain the basic concept of RF Energy Harvesting system. Then the introduction to the microstrip patch antenna concept and design will be introduced. This chapter also give information on the parameter and process involved in designing an antenna.

2.2 RF Energy Harvesting

Energy is everywhere in environment surrounding us and available in many forms such as thermal energy, solar energy, wind energy and radio frequency (RF) energy.