DESIGN OF ANTENNA WITH HARMONIC SUPPRESSION FOR RF ENERGY SCAVENGING

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To my lovely father and mother

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ABSTRACT

The array antenna is required in RF energy scavenging as it provide high gain during signal reception from surrounding sources. Most antennas used in energy scavenging technology deliver a low gain value. In fact, the range of RF power transfer limited. An antenna array is designed to make energy harvesting technology improvement. Advantages of microstrip patch antennas such as low weight, low profile, and low cost made them as perfect choice for communication system engineering. The antenna array was specifically designed for WLAN applications which operate at frequencies of 2.45 GHz. In order to analyze and optimize the performance of the antenna, CST Studio Suite software was utilized. The designed antenna then tested in laboratory.

ABSTRAK

Antena diperlukan dalam penuaian tenaga RF di mana isyarat boleh diserap daripada sumber-sumber sekitarnya dengan gandaan tenaga yang tinggi. Kebanyakan antena yang diaplikasikan pada teknologi penuaian tenaga terkini mempunyai nilai gandaan yang rendah dan jarak bagi pemindahan kuasa tenaga RF adalah terhad. Antena array direkabentuk selaku langkah penambahbaikan teknologi penuaian tenaga terkini. Kelebihan antena 'mikrostrip patch' seperti ringan, profil rendah dan kos rendah menjadikannya sebagai pilihan tepat bagi kejuruteraan sistem komunikasi. Antena telah direka bentuk secara khusus bagi aplikasi WLAN yang beroperasi pada frekuensi 2.45 GHz. Perisian CST Studio Suite telah digunakan untuk menilai dan mengoptimumkan prestasi antena. Antena yang direka telah diuji dalam makmal.

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LIST OF ABBREVIATIONS

RF	-	Radio Frequency
DC	-	Direct Current
AC	-	Alternative Current
CST	-	Computer Simulation Technology
DGS	-	Defected Ground Structures
FR	-	Flame Retardant
CPW	-	Coplanar Waveguide
GSM	-	Global System for Mobile Communication
MEMS	-	Micro-electromechanical systems
RL	-	Return Loss
VSWR	-	Voltage Standing Wave Ratio
MICs	-	Microwave Integrated Circuits
MWS	-	Microwave Studio
VNA	-	Vector Network Analyzer

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This chapter will focus on the description of the overall project. Energy scavenging is a process of capturing signal from several source such as RF source, solar energy or piezoelectric. The RF generator transmitting the radio frequency (RF) which is picked up by a microstrip antenna in the receiver section [1]. This RF energy scavenging system is a combination of an antenna receiver and rectifier which able to receive and then convert electromagnetic waves into DC signal. This system consist of an antenna, impedance matching circuit, rectifier, and load resistance. Figure 1.1 shows the block diagram of RF energy scavenging system.

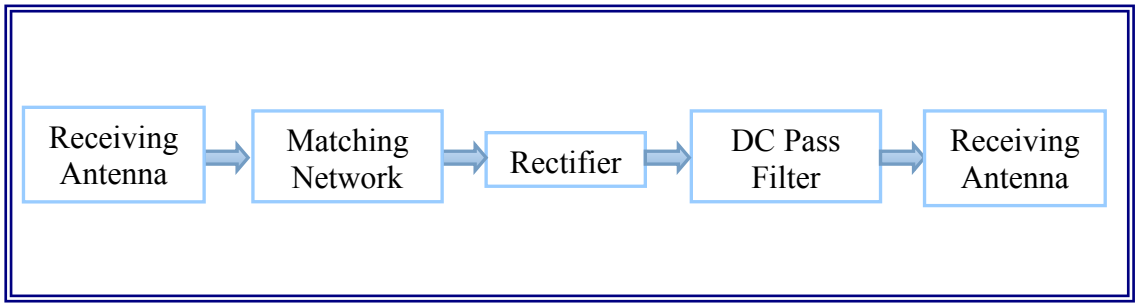

Figure 1.1 : Block Diagram of the RF Energy Scavenging System

The receive antenna collects electromagnetic waves from surrounding sources. In order to provide same efficiency level, the antenna has been used to transfer surrounding energy to receiver. The receive antenna responsible to induce AC current. The frequency at receive antenna is 2.45GHz. The matching network matches the impedance of antenna to the impedance of the rectifier. The DC filter convert AC to allow DC current passing to the load which is placed at the output port to measure the power. The project represents design of antenna with defected ground structure (DGS) to use for harmonic suppression. CST Studio Suite software has been used to design the antenna.

1.2 Objective

The objective of this project is to design an antenna for RF energy harvesting scavenging system that operates at frequency of 2.45GHz. The antenna was analyzed by using CST Studio Suite software. The design of the antenna with defected ground structure (DGS) is expected to suppress higher order harmonics.

1.3 Problem Statement

Recently, the usage of electronic devices such as mobile phone and sensor network is becoming wider. These kind of devices do not have a longer energy of battery. As the usage of electronic devices increase, the energy of battery also increase. Energy harvesting is used to provide unlimited energy of battery as a replacement. Moreover, the project is green technology based as the RF power obtained from the surroundings sources. This system is best solution who undergoes problem for developing wireless broadcasting and communications system generation with free energy.

The combination of curvature slots and notch-loaded with open stub and insert feed initiate harmonic suppression up to third order. However this method contributes rise in weight and cost at the same time system efficiency and performance are reduced [2]. Therefore, array antenna is used to provide good performances in terms of gain, radiation pattern, bandwidth, return loss and system efficiency. Microstrip patch antenna has been chosen for the purpose as it is light weighted and inexpensive.

1.4 Scope of Work

The implementation of this project cover design of the antenna at frequency of 2.45GHz along with design of DGS for RF energy scavenging system with harmonic suppression. This project require understanding on concept of array antenna and relevant techniques. Firstly, all related journals were collected for literature review before design antenna. Design of antenna for single patch then followed by 2x2 rectangular patch. The design was simulated using CST Studio Suite. Once design process completed, antenna fabricated using FR4 board. After done with fabrication process, antenna subjected to testing, analysis and measurement procedures. Finally, the result obtained from the fabricated antenna was compared with the simulation result. The antenna evaluated in term of parameters such as gain, return loss and radiation pattern.

1.5 Methodology

The project is started by research on literature review on antenna and theories on RF energy scavenging system. Then, physical layout for the design antenna constructed by calculating the parameters with microstrip formula. A simulation was done using the CST Studio Suite software. The performances of the design antenna was optimized by some antenna characteristics such as a resonance frequency, return loss, bandwidth, gain, and directivity, radiation efficiency and impedance matching. After completing design process, the antenna was fabricated. The antenna was tested, measured, analyzed and optimized for result loss, bandwidth, realized gain and directivity of an antenna. Then, result of simulation and measurement value compared to justify whether its specification meets the requirement. Figure 1.2 shows the flow chart of the project.

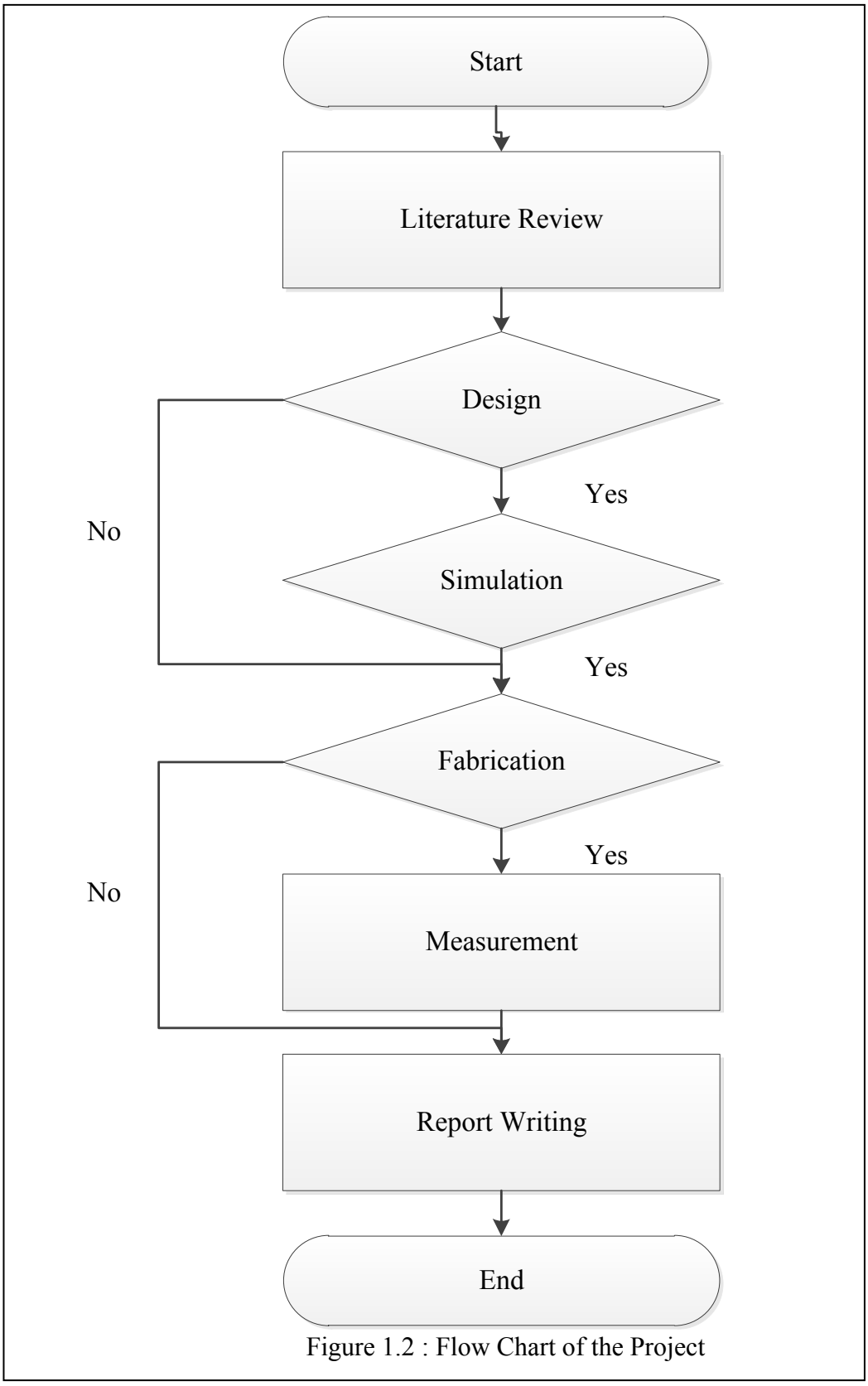

Figure 1.2 : Flow Chart of the Project

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss about the design of microstrip patch antenna at 2.45GHz and feed modeling techniques. This chapter also elaborate about basic antenna parameter which will shows the performance of the antenna.

2.2 Critical Literature Review

As a start, do some research and literature review by finding several journals related to the topic of RF energy harvesting scavenging system. Some information that found to be related with the project has been collected. From the collected data some information was summarized in Table 2.1.

Table 2.1 : Summarize of Literature Review

Journal	Application(Hz)	Technique	Performance
[1]	2.45GHz	Two dc-recombined rectifiers and a cross-slot coupled square patch antenna fed by a microstrip line.	The co-localized dual circularly polarized properties of the antenna avoid the well-known 3 dB. A very low ripple of the output dc voltage and the global conversion efficiency.
[2]	2.45GHz	Notch-loaded and curvature slots at the antenna patch together with an open stub and inset feed transmission line	The proposed patch antenna is able to suppress the unwanted harmonics up to third order.
[3]	2.45GHz	Square patch antenna array 3x3 designed with a circular polarization using an inclined slot at the center.	The array will permit to increase the efficiency of the RF-DC conversion system, by increasing the gain and directly increasing the received power at the input of the rectenna.
[4]	Range of 2GHz -10GHz	A CPW-fed circular slot antenna with a slot on a ground conductor	Second and higher rejection bands are integer-multiple of the first band

[5]	2.45GHz and 5.8GHz	Circularly polarized microstrip rectenna operating on C-band λ=4 microstrip lines and open stubs	The truncated-corner patch antenna achieves the harmonics suppression characteristic by a microstrip feedline
[6]	2.45GHz	3×3 circular polarized antenna array an inclined slot at the center	The design provides a high directivity of its receiving Antenna and also the good radiation efficiency which can reach more than 98% at the operating frequency.
[7]	2.4GHz	Wideband system	.Two systems enable to harvest RF power at 900MHz GSM band (single frequency) and at 900MHz GSM{2.4 GHz Wi-Fi bands.

2.3 Introduction to Energy Harvesting

Energy harvesting is the process of collecting energy from the surrounding resources. To run a device the energy harvesting is used to convert external resources into electrical signal. Some energy harvesting can be convert from a motion signal into electric energy such as wind turbine, water turbine, ocean waves and others. In few past days, there are several new ways establish to harvest the energy by using vibration energy, resonant frequency, magnetic, and microwave. Some of companies and researchers encouraging to bring upcoming ideas to develop the battery lifespan mostly for wireless devices. The size of batteries increases while the environmental pollution also will be increased. The energy harvesting with using of RF which will capture the sources and stored the energy from the ambient sources, hence it will useful for mobiles devices and also the miniature electronic devices. There are several types such as energy harvesting, power harvesting,