INVESTIGATION OF RECEIVING ANTENNA FOR ENERGY SCAVENGING FROM MICROWAVE SIGNAL

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To my lovely father and mother

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ABSTRACT

RF energy scavenging requires an antenna that can support high gain that the signal is absorbed by the around. Most antennas used in energy scavenging technology, delivers a low gain value and range of RF power transfer limited. The antenna array is designed to make energy harvesting technology improvements. The primary trouble is that RF energy scavenging antenna has a profit of less than 10 dB. So, first, to design an antenna array parameters must be recognized. The antenna array is designed for WLAN applications operating at frequencies of 2:45 GHz. CST Studio Suite software is used for simulation and design for a decision. Process simulation must show the return loss for the antenna array ≤ -10 dB, gain, the form of radiation, the percentage achieved, and so the antenna array.

ABSTRAK

Penuaian tenaga RF memerlukan antenna yang dapat menyokong gandaan yang tinggi supaya isyarat disekeliling dapat diserap dengan lebih banyak. Kebanyakkan antenna yang digunakan dalam teknologi penuaian tenaga ini, mempunyai nilai gandaan yang rendah dan jarak pemindahan kuasa untuk tenaga RF menjadi terhad. Antena array direkabentuk bagi membuat penambahbaikan teknologi penuaian tenaga ini. Masalah utama antenna penuai tenaga RF ialah mempunyai gandaan yang kurang daripada 10 dB. Oleh itu, pertamanya, parameter untuk merekacipta antena array ini mesti diketahui. Antena array ini direka untuk aplikasi WLAN yang beroperasi pada frekuensi 2.45 GHz. Perisian CST Studio Suite digunakan untuk simulasi dan rekaan bagi mendapatkan keputusan. Proses simulasi mestilah menunjukkan kehilangan balikan bagi antenna array ≤ -10 dB, gandaan, bentuk radiasi, peratusan dicapai, dan sebagainya bagi antenna array.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will introduce the overall objective of the project incurred. Energy scavenging is the process of capturing energy that are available from different source such as RF source, solar energy or piezoelectric [1]. Radio frequency (RF) energy scavenging is the process of capturing around RF signal where the signal is in the form of electromagnetic energy in the air and convert this signal into an appropriate DC power. This system is a combination of an integrated antenna receiver, and an efficient rectifier circuit to convert RF energy into DC signal. The basic system consists of scavenging RF microwave antenna, impedance matching network, rectifier circuit, the next stage low pass filter for DC route and load resistance. Figure 1.1 shows the basic block diagram of RF energy scavenging system.

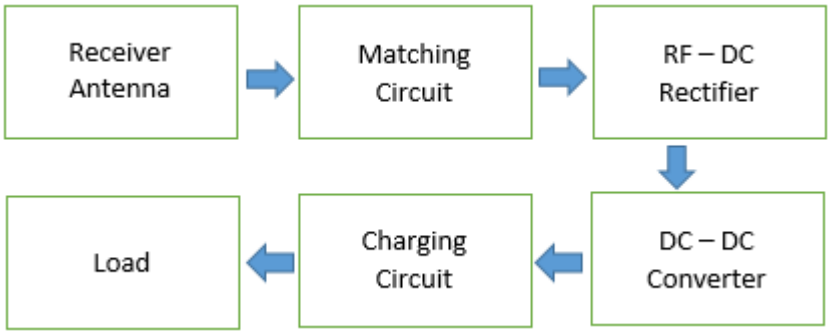

Figure 1.1: RF energy harvesting block diagram

The RF energy system requires the use of antenna as an efficient RF signal power receiving circuit [2]. In the RF signal transmission system generated, amplified, modulated and applied to the antenna. In the meantime, the receive antenna system to collect electromagnetic waves through the antenna and induce alternating Currents is used by the receiver. The antenna capability to transfer energy from the atmosphere to the receiver with the same efficiency as it transfers energy from the transmitter into the atmosphere. The RF signals received by the antenna will be transformed into a DC signal by a diode-based rectifier circuit or a voltage multiplier. This project will represent the design of antenna to use for rectifying circuit based on a concept of RF energy scavenging system. The CST Studio Suite software will be used for the antenna design.

1.2 Objective

The objective of this project is to design an antenna for RF energy scavenging system operating at a frequency of 2.45 GHz. A type of antenna designs have been proposed in this project as part of accepting the energy scavenging system. The design of the antenna that is used to rectify circuit is expected to achieve higher efficiency of the RF-DC conversion for maximum power transfer.

1.3 Problem Statement

In last few years, there has been a rapid increase in the use of wireless devices in applications such as mobile phones and sensor networks. These devices are powered by a portable device, and limited energy of battery. This means an increase in the use of the application will result in the battery being used has also increased and these batteries need to be replaced often. These batteries contain heavy metals, which if we are not properly disposed of it can leak it contains into the environment pollution increases. Consequently, the use of green technologies such as RF power system is one of the solutions to overcome this problem for developing wireless broadcasting and communications systems generated the free energy.

The main problem in the RF energy scavenging system is the amount of energy captured from the around the RF source is very low. This effect may be due to low levels of RF power levels and antenna mismatch to the rectifier. To capture the maximum power, the receiving antenna should be well designed, taking into consideration the many factors to achieve impedance matching between antenna and rectifier at the operating frequency and to obtain maximum power transfer and minimize transmission loss from the effects of PCBs. Hence, to convert more of the antenna surface incident RF power to DC power, high efficiency RF to DC conversion required by correcting circuit.

1.4 Scope of Work

The main objective of this project is to design a narrow band antenna using circuit rectify for energy scavenging system. The first step in the design process is to find and collect information about the project such as the journals and papers on the internet. This project will focus on the design and analysis, testing and measurement of microstrip patch antenna captures electromagnetic energy from the RF signal being transmitted by the communication system in the frequency range of the WLAN band (2.45 GHz). Computer Simulation Technology or CST Studio Suite will be used for the antenna design process. The type of antenna will be designed that is a rectangular patch antenna array. After the complete design process, the next procedure is to fabricate circuits and do testing and measurement procedures. Then, the results will be compared to the measurement results and the actual results. Other antenna parameters such as return loss level, gain, and radiation pattern also will be look of antenna design.

1.5 Methodology

This project will begin by doing the literature review process to study and learn about the antenna fundamentals, the rectifier circuit and basic RF energy scavenging system. After all the parameter involves in this antenna design is calculated, the physical layout of the design antenna will be constructed. Then the simulation will be carried out by using the CST software. The design of the antenna will be optimized by considering all antenna basic characteristics such as a resonance frequency, return loss, bandwidth, gain, and directivity. After completing the design process, the antenna will be fabricated. The fabricated antenna then will be measured to observe the result of return loss, bandwidth, gain and directivity of the antenna. When all the specification meets the requirement, the fabrication process of the antenna will be carried out. Next the testing and measurement of the fabricated antenna will be carried out hence again will compare it with all the calculated and simulated results. All experimental results will be included in the final report. Figure 1.2 shows the flow of the project development.

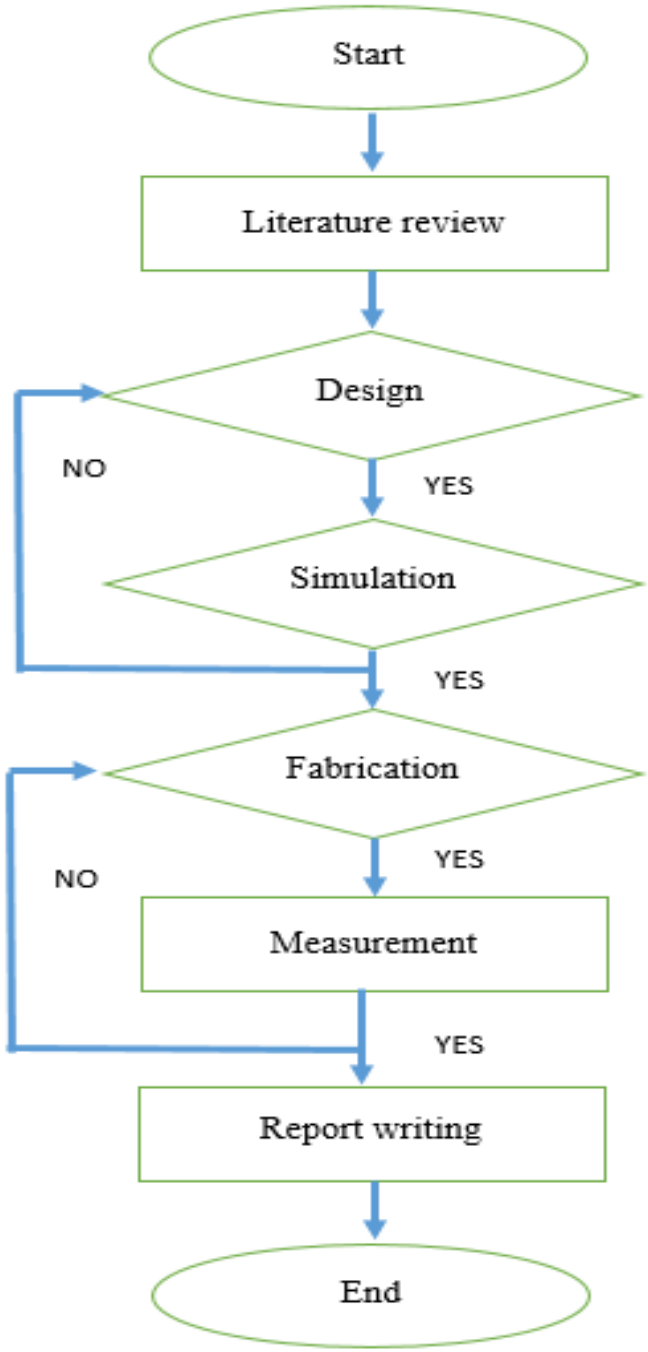

Figure 1.2: Flowchart of project

1.6 Contribution of Project

At this time, a kind of low-power devices can be operated and charged with use of RF energy is close to us. To use short-distance for a low-power transmitter, an energy scavenging system can be used to trickle charge a number of devices for example GPS or RLTS tracking tags, medical sensor, and consumer electronics devices such as mobile telephones. For long-distance, this system can replace the battery or battery-free sensors known as to control Heating, Ventilation and Air Conditioning also known as HVAC, structural monitoring, and industrial control. Energy scavenging system depends on the power requirements and operations for power can be transmitted continuously, scheduled, or on request. Efforts to eliminate future maintenance to replace the battery can be done using large-scale sensor to reduce labour costs.

RF energy is suitable Candidates to recharge wirelessly on a single set of batteries, in which the device will function normally for a week, a month, or a year. In certain applications, Energy scavenging can be utilized as a wireless power enhancer. Where it is used to increase the battery life or setting off during sleep microcontroller.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses some issues that are most important in designing the high gain rectangular patch antenna at 2.45 GHz. This chapter also discussed about basic antenna parameter that will affect the performance of the antenna.

2.2 Critical Literature review

Before starting the design process, research was carried out by performing a review of the literature in several journals related to research the topic of RF energy harvesting system. The literature review was performed on a journal to collect related

information and facts that can be used in the design process of this project. Table 2.1 summarizes the sample literature review was done.

Table 2.1: Summarize of journals for literature study

Journal	Application	Method	Improvement
[20]	2.45 GHz (ISM Band)	Design a 10mm microstrip antenna by using shorting pin technique and common PCB	Enhance the impedance bandwidth and gain of the microstrip antenna
[21]	2.45 GHz & 5.2 GHz (ISM & Bluetooth Band)	Adjust two different multiplying factor and setting the gaps between the two patches.	The expected result achieved for return loss and radiation pattern
[22]	2.45 GHz (ISM band)	This system developed by using miniaturize 2nd iteration koch fractal patch antenna and two stage Dickson charge pump voltage-doubler rectifier circuit	Rectenna harvests enough energy from a commercial RFID interrogator 3.1 meters away (4W EIRP at 2.45 GHz ISM band) to power up a 1.6 V LED
[23]	2.4 GHz (WLAN Band)	This antenna design by using Electromagnetic Band Gap (EBG)	Reduce coupling losses with two patch antenna layer and wider bandwidth also increases the directivity.
[24]	5.8 GHz (RFID Application)	This design using the orthogonal ports, both Transmit and receive functions can be implemented on the same antenna.	Slot length affects the resonant frequency and produce high isolation, good cross-polarization and radiation levels are high waist with 9.3dBi gain.

2.3 Antenna Theory

In this antenna theory, basic and understanding of antenna theory is discussed. An antenna is an electrical device which converts electric currents into radio wave or radio wave into electric currents. Antenna usually used with a radio transmitter or radio receiver. In transmission, radio transmitter applies an oscillating radio frequency electric current to the antenna's terminals and the antennas radiate the energy from the current as electromagnetic waves. Antennas that excite an electrical field are referred to as electrical antennas; antennas exciting a magnetic field are called magnetic antennas. The oscillating electrical or magnetic field generates an electromagnetic wave that propagates with the velocity of light, c. In reception, an antenna intercepts some of the power of electromagnetic waves in order to produce tiny voltage at its terminals. An antenna can be used for both transmitting and receiving.

In other words, an antenna only converts an electromagnetic signal to an electrical signal at receiver or transmitter. If there is 100 percent of efficiency, they radiate no more power than is delivered to their input terminal. This is because all the energy of the signal is absorbed.

2.4 Antenna Properties

There are many of basic properties that are used to describe the performance of the antenna. There are including impedance, return loss, VSWR, bandwidth, radiation pattern, 3 dB bandwidth, gain and polarization.