DEVELOPMENT OF INTEGRETED RF RECTIFIER AND POWER STORAGE FOR PORTABLE CHARGING SYSTEM

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DEDICATION

I dedicate my dissertation work to my family, my supervisor and friends. A special feeling gratitude to my loving parents, my father Joseph Bitog and my late mother Minin Mawok whose words of encouragement and push for tenacity ring in my ears. My brothers Justeen, Cyrel and Mike, my sisters Angeline, Nancy, Martha, Joan and Imelda which have never left my side and are very special. Dedication goes to my hardworking and reliable supervisor Assoc. Professor Dr. Zahriladha bin Zakaria which guided me throughout the process of completing this work. I also dedicate this dissertation to all lectures and lab assistants in Faculty of Electronic and Computer Engineering and to my dearest colleagues

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ABSTRACT

Radio Frequency Energy Transfer is a research area of on demand technology, related to sustainability which could turn into a promising alternative to existing energy resources. Energy harvesting offer a potential solution to the barrier faced by Wireless sensor networks (WSNs) in order to supply power without the need of wiring and also replacement of battery. One of the crucial parts in RF Energy Harvesting is rectifying circuit that converts the RF signal to DC signal. In this project an optimum rectifying circuit is designed along with the analysis of DC converters and power storage for portable charging system, the rectifier design is simulated by using Advance Design System (ADS) 2011 software then fabricated and measured in the laboratory. Frequency 2.45GHz are proposed for this project. This rectifying circuit consists of a single stub matching network and a voltage doubler. At the input power level of 20dbm, the measured result shows a RF to DC conversion efficiency achieving 61.4% with the corresponding DC output voltage of 3.196V with current output of 5.3mA.

ABSTRAK

Penuai tenaga radio frekuensi adalah bidang penyelidikan mengenai teknologi permintaan, yang berkaitan dengan kelestarian tenaga dimana ia menjanjikan alternatif bagi menggantikan sumber-sumber yang sedia ada. Penuai tenaga menyediakan penyelesaian berpotensi bagi masalah yang dihadapi oleh rangkaian sensor tanpa wayar (WSNs) bagi membekalkan kuasa tanpa memerlukan pendawaian dan atau bagi menggantikan bateri. Salah satu bahagian yang terpenting dalam penuai tenaga RF adalah litar penerus yang menukarkan isyarat RF kepada isyarat DC. Dalam projek ini, litar penerus yang optimum telah direka brserta dengan analisis pengubah-pengubah DC dan penyimpan tenaga, reka bentuk litar penerus disimulasi, dibina dan diukur dengan menggunakan perisian Advance Design System (ADS) 2011. Frekuensi 2.45GHz telah dicadangkan untuk projek ini. Litar penerus ini terdiri daripada "single stub matching network", dan litar voltan pengganda. input kuasa pada paras 20 dBm, keputusan ukuran menunjukkan penukaran isyarat RF kepada isyarat DC mencapai kecekapan pada 61.4% sepadan dengan keluaran DC voltan berjumlah 3.196V dengan keluaran arus berjumlah 5.3mA.

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LIST OF ABREVIATIONS

RF	- Radio Frequency
RFID	- Radio Frequency Identification
DC	- Direct Current
ADS	- Advance Design System
GSM	- Global System for Mobile Communication
ISM	- Industrial, Scientific and Medical
SPICE	- Simulation Program with Integrated Circuit Emphasis
UTMS	- Universal Mobile Telecommunications System
WIFI	- Wireless Fidelity
UHF	- Ultra High Frequency
TEM	- Transverse Electromagnetic Mode
EM	- Electromagnetic
USB	- Universal Serial Bus

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CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Ambient energy harvesting draw an interest in free energy scavenging as it provide a maintainable energy sources for future development and fortification of the environment. Due to the distress of a shrinking conventional energy supplies, the motivation on discovering an alternative renewable energy form are rapidly growing. A significant research struggle upon a harvesting energy from an inexhaustible sources such as solar energy, thermal energy, electrostatic energy piezoelectric energy, waste water and a microwave energy [1]. Among these types of green energy harvesting, RF energy scavenging has been growing famously as the obtainability of ambient RF energy

Increased due to the development in broadcasting and wireless communication system. Moreover, the development of a mobile electronic devices, wireless implant healthy monitoring [2],micro-sensor and RFID system to operate without a batteries has triggered an intention for RF energy harvesting. Scavenging microwaves energy from an ambient environment and rectify to obtain a DC power wirelessly through a wireless transmission has been the issue of a research for decades. The concept of RF energy harvesting use the idea of scavenging a transmitted RF energy from an ambient environment then convert it into a DC signal to power up circuit or storing it for a future use[3]. Mainly, the conventional RF to DC converter consist of a few parts including antenna, input matching circuit, rectifier, output matching circuit and a load [4]. The antenna will capture the electromagnetic radiation and the matching circuit will optimizing the power delivered upon the RF energy extraction then the rectifier will rectify and convert those extracted signal into DC signal [3] via rectifying element as illustrated in figure 1.

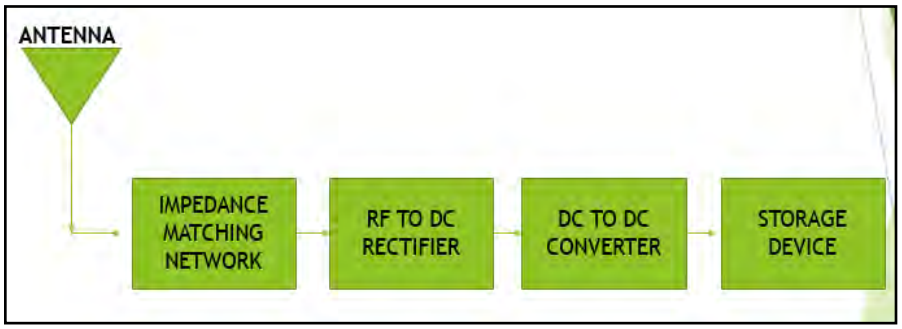


Figure 1.1: RF energy harvesting system block

This project present two goals which the first for low power application powering and recycling the RF energy. As wireless device is a famous trend in which most of the electronic device are no longer attached to the wire but then powered by the bulk of battery which need to be recharge periodically causing portability issues for the device that located in an inaccessible places such as node sensor. As the ability of the RF rectifier which scavenging the RF energy from an ambient environment, it can be the main source of power to charge the battery of the electronic devices.

1.2 PROBLEM STATEMENT

Laterally, a rapid growing on an advancement of a wireless technology has brought an intimation of transmitting power wirelessly as one of the solution to replace a power cord and a battery needs to power up a variety of an electronic devices. Traditionally, most of an electronic devices are attached by wires or powered by batteries which causing a user's flexibility issues such as an electronic devices that attached with wire and a wireless devices which is powered by only a batteries that required to be charged periodically making the system less autonomous. Hench, as the energy is an essential requirement in all system, an environment friendly approach provides an opportunity to harvest the microwave signal from an ambient environment that commonly known as a RF energy harvesting. The existing design of a rectifier DC conversion that has been proposed in many research facing an issues of getting low output power as the energy captured from RF ambient source is low due to the effect of mismatching problem between antenna and rectifier. Moreover, even there is less issues of matching problem between an antenna and the rectifier, some problem as unstable voltage output is another concern to acquire clean DC output due to the changes of RF input power behaviour. Thus, in this project, an ideal design of a DC conversion of RF rectification is proposed together with an addition of a storage device as to deal with the unstable power output issues.

1.3 OBJECTIVE

The objective of this project is to study and to analyse the characteristic of an impedance matching network, RF rectification, power storage and a step up DC/DC converter. Aside, design a cascade circuit with an ideal output efficiency along with a fabrication and evaluation process by applying laboratory skills.

1.4 SCOPE OF WORK

This project present a purpose of designing a RF circuit model include matching network, rectification circuit which convert RF energy to DC energy efficiently with a typical storage device. The project initially start with an understanding and analysing the rectifying circuit which consist of matching circuit and voltage multiplier. Next, collecting an information related to DC to DC converter and a storage device. All information are obtained through journal, books and a paperwork via an internet. The main focus of this project is designing a RF to DC rectifier with an ideal efficiency output that runs under proposed frequency of 2.4 GHz. The performance of the rectifier are depends on a matching circuit as it will help to match an impedance between antenna and the rectifier to achieve a good impedance. Beside that a proper selection of a diode and a resistance load value since a diodes and load play an important role in affecting an output efficiency. Moreover, a DC to DC converter as to boost up the rectifier output then a storage unit to store energy for a portable charging unit. The designing and a simulation of the rectifier circuit are using an Advance Design System (ADS) software. Lastly, the complete fabricated circuit, test run are conducted in a laboratory.

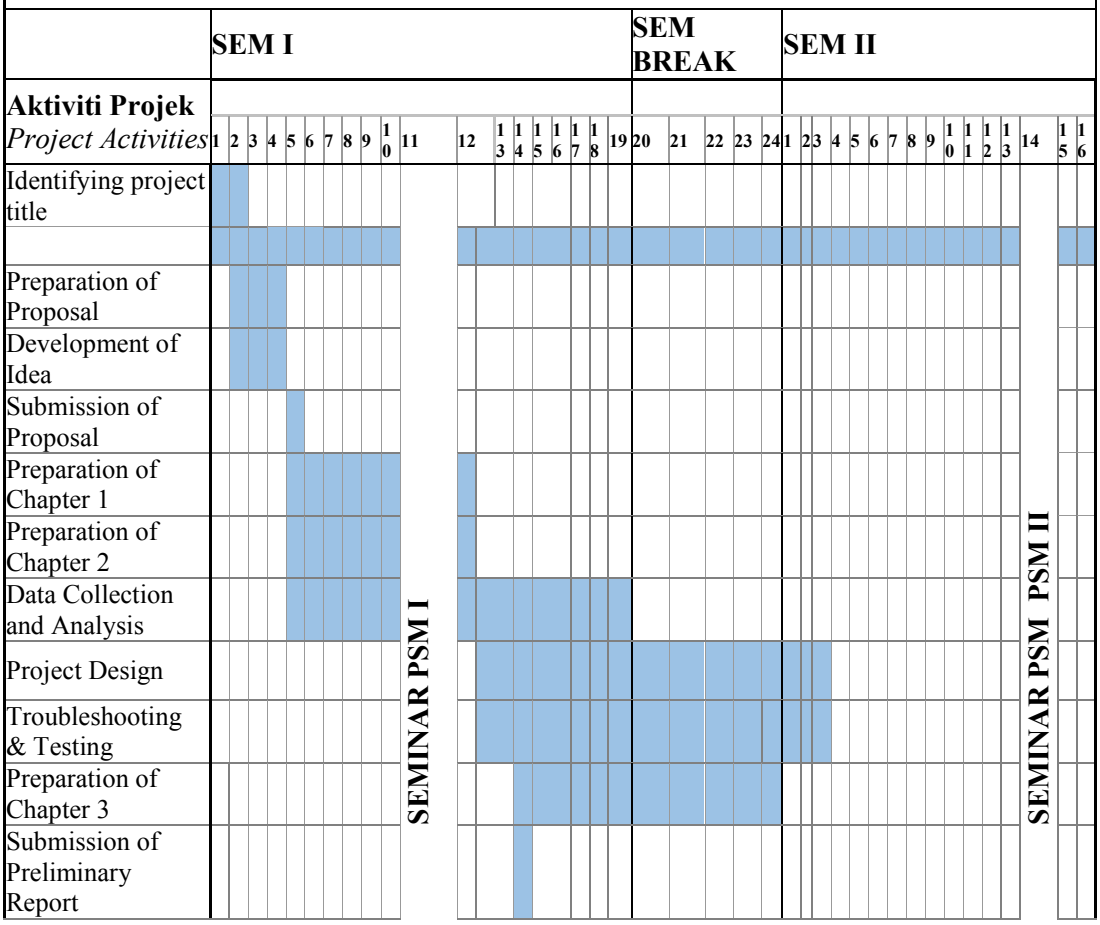
1.5 PROJECT PLANNING

The Gantt chart in table 1 shows the work flow that need to be done according to the time established. The Gantt chart helps to guide and complete each task on time.

Table 1.1: Project Gantt-chart

A. PERANCANGAN PROJEK
PROJECT PLANNING (GANTT CHART)

Senaraikan aktiviti-aktiviti yang berkaitan bagi projek yang dicadangkan dan nyatakan jangka masa yang diperlukan bagi setiap aktiviti.
List all the relevant activities of the proposed project and mark the period of time that is needed for each of the activities.



1.6 THESIS ORGANIZATION

This thesis consist of five chapter, which in the first chapter describing about the project introduction consist of research background of RF energy harvesting including problem statement, objectives, scope of project and thesis organization. In a second chapter the crucial part of the rectifier is discussed such as RF energy harvesting characterisation, RF rectifier topologies, diode specification, load, impedance matching network and all relevant topic that includes in project. In the third chapter, methodology of project competition is described such as resistor, diode and matching network analysis, lumped element transformation, fabrication and measurement process. In a fourth chapter the relevant analysis result of the matching network, load resistor, types of diodes, DC converters, power storage device and the rectifier are highlighted which some of the result are based on simulation and comparisons between simulation and measurement result and in the fourth chapter the overall discussion about the findings are specified. The last chapter of the thesis is specifically emphasizing on project conclusion, improvement and suggestions.