AN IMPROVED RECTENNA DESIGN FOR RF ENERGY HARVESTING

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by

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LIST OF ABBREVIATIONS

RF	radio frequency
WSN	wireless sensor network
IPS	Institut Pengajian Siswazah
USM	Universiti Sains Malaysia
WLAN	wireless local area network
VSWR	voltage standing wave ratio
VS	versus
etc	et cetera
TV	television
DC	direct current
AC	alternating current
PCB	printed circuit board
ADS	Advanced Design System
GSM	Global System for Mobile Communications
DTV	digital television
3G	third generation
FCC	Federal Communication Commission
MCMC	Malaysian Communications and Multimedia Commission

REKA BENTUK REKTENA YANG DITAMBAHBAIK BAGI PENUAIAN TENAGA RF

ABSTRAK

Pada masa ini, penuaian tenaga frekuensi radio (RF) telah menjadi semakin popular dalam teknologi hijau kerana penambahan daripada stesen pangkalan televisyen, stesen pangkalan telefon mudah alih, Wi-Fi, Bluetooth dan lain-lain. Banyak kajian telah dilakukan ke atas penuaian tenaga RF. Walau bagaimanapun, tenaga RF yang terdapat di sekitar masih terlalu kecil dan kecekapan penukaran di bahagian pengganda adalah sangat rendah. Oleh itu, dalam kajian ini, reka bentuk rektena untuk litar penuaian tenaga RF dalam aplikasi penderia untuk menuai tenaga RF daripada sumber berdedikasi dan ambien telah direka dan dibentangkan. Kajian ini membentangkan tiga reka bentuk rektena yang memberi tumpuan kepada tiga frekuensi yang berbeza iaitu GSM 900, GSM 1800 dan band Wi-Fi kerana kewujudan isyarat tersebut di sekeliling kita. Kajian ini dijalankan dalam beberapa peringkat yang melibatkan reka bentuk litar pengganda, reka bentuk antena, ujian dan pengukuran bagi setiap bahagian, kombinasi pengganda dan antena untuk membentuk rektena serta ujian dan pengukuran untuk rektena. Rektena yang beroperasi pada 915 MHz dapat mencapai voltan pengeluaran sebanyak 0.115 V apabila menuai isyarat RF dari Nokia 100 pada jarak 30 cm. 0.067 V boleh diukur apabila rektena 915 MHz menuai tenaga RF sekitar USM. Rektena yang beroperasi pada 1.8 GHz dapat mencapai voltan pengeluaran sebanyak 0.273 V apabila ia menuai tenaga RF daripada Nokia 100 pada jarak 30 cm. Apabila rektena yang menuai tenaga RF daripada sekeliling, 0.042 V voltan pengeluaran boleh dicapai. Voltan keluaran 0.214 V boleh dicapai apabila rektena 2.4 GHz menuai tenaga RF dari modem router TP-Link dengan jarak 50 cm. 0.037 V voltan pengeluaran boleh

diperolehi apabila rektena 2.4 GHz menuai tenaga RF sekeliling. Rektena yang direka menunjukkan prestasi yang baik dan menunjukkan peningkatan daripada kajian sebelumnya tetapi masih mempunyai ruang untuk diperbaiki pada masa akan datang.

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ABSTRACT

Nowadays, Radio Frequency (RF) energy harvesting has become increasingly popular in green technology due to the high rise of the television base stations, mobile phone base stations, Wi-Fi, Bluetooth and others. Many researches have been done on harvesting the RF energy. However, the RF energy available around is still too small and the conversion efficiency at the multiplier part is very low. Thus in this research, an improved rectenna design for RF energy harvesting circuit for WSN application has been designed to harvest the RF energy from a dedicated and ambient sources is presented. This research presents three rectenna design which focusing at three different frequencies which are GSM 900, GSM 1800 and Wi-Fi band due to the availability of those signal around us. This research is progressed in few stages involving designs of multiplier circuit, designs of antenna, test and measurement of each part, combination of multiplier and antenna to form rectenna and rectenna test and measurement. Rectenna operating at 915 MHz is able to achieve an output voltage of 0.115 V when harvesting RF signal from Nokia 100 at a distance of 30 cm. 0.067 V can be measured when 915 MHz rectenna harvest RF energy around USM. Rectenna operating at 1.8 GHz able to achieve an output voltage of 0.273 V when it harvest the RF energy from Nokia 100 at a distance of 30 cm. When the rectenna harvest the ambient RF Energy, 0.042 V of output voltage can be measured. Additionally output voltage of 0.214 V can be achieved when the 2.4 GHz rectenna harvest RF energy from a TP-Link modem router with a distance of 50 cm. A 0.037 V of output voltage can be obtained when 2.4 GHz rectenna is harvesting ambient RF

energy. The designed rectenna are able to perform well under three conditions or environments. Subsequently they show significant improvements over other related works and in turns have space for further improvement in the future.

CHAPTER ONE

INTRODUCTION

1.1 Significant of Project

Advance developments in sensing technology or mobile handheld devices involving microprocessor and miniaturized radio transceivers have rapidly increased the development of smart structures and machines to be realized. The dream for the future is a universal smart wireless sensor network (WSN) which can autonomously operate and able to accommodate structural or systematic health monitoring, embedded test and evaluation and condition based maintenance of public properties such as bridges, trains and aircraft. WSN is able to alert users or systems of any in-coming disasters or even eliminating the unnecessary scheduled maintenance, thus reducing the cost of human resources. This in evidently improves the safety and reliability of public transportation, industrial manufacturing and military system infrastructure while greatly reduce the maintenance cost.

However in order for the sensor networks to be fully autonomous, there must be a need to eliminate the use of battery and provide alternatives that can both harvest and store the energy continuously; self-sustaining the whole network system. Without the need for battery replacement, there will be no service disruption, thus the maintenance cost will be low. Subsequently, energy harvesting technology has a high potential in replacing batteries or to prolong the life of rechargeable batteries for low power electronic devices.