بسم الله الرحمن الرحيم

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تم رفع هذه الرسالة بواسطة / هناء محمد علي

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
CAIRO - EGYPT

Electronics and Communications Engineering Department

Investigations on RF Wireless Power Transfer System

A thesis submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Electrical Engineering

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The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Dalia Sadek

Published Papers

1. Dalia Sadek, Abdelhalim Zekry and Heba A. Shawkey," Multiband Triple L-Arms Patch Antenna with Diamond Slot Ground for 5G applications “, The Applied Computational Electromagnetics Society Journal. ACES JOURNAL, Vol. 36, No. 3, March 2021, p302-307. DOI: 10.47037/2020.ACES. J.360310.
2. Dalia Sadek, Abdelhalim Zekry and Heba A. Shawkey, " Compact and High Efficiency Rectenna for Wireless Power Harvesting Applications ", International Journal of Antennas and Propagation., 15 December 2021, Volume 2021. DOI:10.1155/2021/1109850.
3. Dalia Sadek, Abdelhalim Zekry and Heba A. Shawkey, "10 GHz Compact Shunt-Diode Rectifier Circuit Using Thin-film Ag/AZO Schottky Barrier Diode for Energy Harvesting Applications”, International Conference on Human-Computer Interaction, Accepted.

Abstract

Due to the increased usage of portable electronics such as laptops, mobile phones, wearable /implantable sensors, s etc., wireless power transmission systems have grown in popularity in recent years. Previously, these devices were powered by a rechargeable battery. Wireless power transmission offers the potential to enable a variety of portable electronic usage devices when the battery cannot be used (due to its size or weight) or where recharging the battery with a wired charger is impractical. Energy harvesting systems are becoming increasingly popular. The antenna is connected to a rectifying unit, which is the system's most important component (rectenna). This thesis focuses on the analysis, design, and measurement of two designs of tiny RF wireless power transfer antenna; a rectifier circuit (rectenna), and matching circuit are the three primary blocks that make up the system. Operating in 5G band. The complete rectenna is implemented in three stages:

The first stage was the design and fabrication of a microstrip patch antenna with a multiband response. A diamond-shaped ground slot is added to control and increase the bandwidth of the resonant frequency. Microwave Studio by Computer Simulation Technology is used to test the antenna (CST). The recommended circuit is built on a ROGERS (RO4003c) substrate. The overall dimensions of the antenna are 16.5mm x16.5mm x 0.81 mm. The antenna is designed to resonate at 10,13,17 and 26 GHz with 10 dB impedance bandwidths of 0.67,0.8,2.45 and 4.3 GHz respectively. The multiband antenna has sufficient realized gain of 4.95, 5.72, 4.94, and 7.077 dB respectively.

The second stage of this thesis is that two rectifier designs with matching circuits have been fabricated, a half-wave rectifier with a shunted Schottky diode and a voltage doubler rectifier. The circuits of both rectifiers are set to 10 GHz center frequency and implemented using a 0.81mm Rogers (RO4003c) substrate. The overall size of the shunted rectifier is only 13.3 mm X 8.2 mm X 0.81 mm and 19.7 mm X 7.4 mm X 0.81 mm for the voltage doubler rectifier. Then the antenna with the rectifier and matching circuit are combined to obtain a complete system for wireless power transfer, then measurements for the whole system. The ROHDE&SCHWARZ ZVA6 Vector Network Analyzer (VNA) is used to measure scattering parameters. The RF/microwave signal generators Anritsu MG3697C are used to transmit a microwave signal to a horn. The DC output voltage for both systems is then measured and compared for high voltage output acquired through

RF to DC conversion using a voltmeter attached to the wireless power transmission system under test. With 300 **Ω** load resistance and 0.51 V output voltage, the highest conversion efficiency of the rectenna with a shunted diode half-wave rectifier is 41%, compared to 50% for the rectenna using a voltage doubler rectifier with 650 **Ω** load resistance and 1.1 V output voltage. It is important to notice that the voltage doubler rectifier circuit has a higher efficiency than the shunted rectifier circuit. The suggested WPT system's measured performance is compared to that of existing systems to demonstrate its suitability for wireless power harvesting applications.

The third stage is to design a thin-film Ag/AZO Schottky Barrier Diode device consisting of 3 layers: a commercial copper tape as the flexible substrate, a thin-film of p-type semiconductor nanoparticle-ink AZO and a silver measuring electrode. The device area is 1 mm^2 and implemented in 280nm thickness for the AZO. The proposed thin-film Schottky diode (TFSD) is implemented with 280nm thickness in the complete shunt rectifier circuit on 0.81mm Rogers (RO4003c) substrate. To provide the microwave signal that is input to the rectifier, an Anritsu MG3697C RF/Microwave signal generator is used at the intended frequency of 10 GHz. The DC output voltage for the rectifier is then measured using a voltmeter connected to the rectifier under test (RUT). With 300 load resistance and 0.3 V output voltage, the rectifier's maximum conversion efficiency is 35 percent.

Table of Contents

Table of Figures

List of Tables