Overview of Wearable and Flexible Rectenna Design for Energy Harvesting

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ABSTRACT: Energy harvesting is a fast expanding topic in many scientific and engineering related disciplines, due to the extreme necessity to discover answers of the world's power challenges. Based on previous work, there are many limitations and drawbacks in the currently used technique, such as low power conversion efficiency or an increase in the number of antenna elements enlarges the overall aperture size of the rectenna, resulting in larger and more difficult to install devices, limiting the potential for further enhancement in the conversion efficiency. This paper provides an overview of different types of rectifying antenna (rectenna) designs used for RF energy harvesting, allow wireless microwave energy transmission to be established. The most significant characteristics in rectenna design are studied and compared, including conversion efficiency, antenna gain and polarisation, rectifier element, and overall performance of the rectenna.

Keywords: *Wearable rectenna; wireless energy; energy harvesting.*

1. INTRODUCTION

Wireless power transfer technology is now widely used in mobile, industrial, and medical applications. Wireless power transfer technology can eliminate the need for cables and batteries. As a result, it is extremely easy and secure for all users.[1]

Rectifying-antennas (rectennas) have a significant impact on the amount of DC power transmitted to a load. The rectenna's antenna element has a direct impact on the radiation to AC harvesting efficiency, which can affect the harvest power.[2] Rectenna is a device that converts radio waves into electrical signals by using a rectifying bridge circuit that is directly linked to a basic antenna. The antenna's common purpose is to be used in the transmission of microwave radiation.[3], [4] While, the function of the rectenna is to collect RF energy from the environment and transfer it through the circuit. This provides high efficiency for converting microwaves to electrical energy. [5]

The thought of using radio-frequency (RF) energy to power low-power electronic devices has increased in popularity as a way of replacing batteries and save cost on maintenance. Wireless energy harvesting through the use of rectifying antenna (rectenna) technology is a viable option for converting ambient RF power to useable DC power. Over the last ten years, many progress has been achieved in the development of the rectenna, which is the most extensively used device for wireless power transmission (WPT) and energy harvesting.[6]

2. METHODOLOGY

In this review paper, there have some rectenna designs that have been studied based on different rectenna parameters. Many researches aimed to improve their rectenna design by using different techniques and methods. As example, author in [7] dividing a planar rectenna topology into two functional pieces, then recombining the two portions into a new topology to reduce rectenna size The suggested topology not only lessens the rectenna design cycle time, but also allows for simple implementation at the needed frequency ranges at a very cheap cost. A 2.45 GHz rectenna system is developed and measured for validation to demonstrate microwave performance. Figure below show topology of rectenna design proposed by [7].

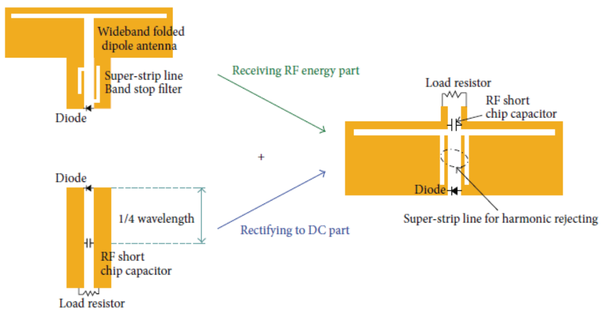

Figure 1: Combination design for a new compact topology rectenna.

Author in [8] shows a new ultra-compact radio frequency (RF) energy harvester built on a flexible substrate. The proposed rectenna is intended to work in the 2.4GHz ISM band. The rectifier incorporates a dual transmission line tapered matching network that enables compactness, flexibility, and up to 40% efficiency. The rectifier is then combined with a tiny monopole antenna to create an ultra-compact, efficient, and versatile rectenna. The system is distinguished by a variety of bending configurations that provide excellent and steady performance. It is proven that the suggested flexible harvester exhibits a variable in collected power of less than 57% for different bent states.

This article in [9] presents a new lightweight radio frequency (RF) energy harvesting device that is small and compact. A dual-tapered transmission line-based matching network is used in the system to extend the rectification capabilities of an integrated Schottky diode. This architecture is shown on a 2.4 GHz rigid harvesting system, with up to 58 percent power conversion efficiency over 0 dBm input RF power. It performs similarly to a typical open circuit shunt-stub matching network references rectifier. The rectifier, combine with a small monopole antenna, is then optimised for a flexible substrate, yielding an efficiency of about 50% at 0 dBm input power. Despite large load fluctuations, the rectifier displays almost flat efficiency across the 2.3–2.5 GHz frequency range.

The article in [10] focuses on the development of a wearable rectenna for harvesting low-power RF energy for a biomedical device attached to the human body. Cordura fabric was chosen as the wearable textile material for on-body application. The textile rectenna is designed to capture RF energy at the WiFi frequency range of 2.45 GHz. The rectenna includes a rectifier and a linearly polarised patch antenna. The rectifier is a single-stage full-wave Greinacher rectifier with an added radio frequency choke (RFC) to boost the output voltage. The output DC voltage of the rectenna can reach 2.2 volts when the RF power is swept from -40 dBm to 0 dBm. It responds admirably when applied to the human body. Since this maximum power transmission distance in an indoor WiFi environment is 150 cm, the maximum output voltage of a 2x2 array rectenna is about 1.05 volts.

3. RESULTS AND DISCUSSION

Table below show some comparison of rectenna design based on antenna gain, input and output power, also the conversion efficiency when the frequency around 2.45GHz.

Table 1: A comparison of several rectenna designs

Ref	Frequency	Antenna Gain	Input power	Output power	Eff	Type of rectifier
[7]	2.45GHz	2.05dBi	30dB	NA	72.9%	Schottky Mixer diode
[8]	2.4GHz	NA	0dBm	NA	40% - 57%	Dual-tapered transmission line
[9]	2.4GHz	180MHz	0dBm	NA	50% - 58%	Dual-tapered transmission line
[10]	2.45GHz	-25dB	NA	1.05V -2.2V	NA	Greinacher rectifier

4. CONCLUSION

As a conclusion, this paper provides an overview of the rectenna design with frequency range around 2.3 GHz until 2.5 GHz. The design is compare and evaluate based on some parameter selected such as conversion efficiency, antenna gain and polarisation, rectifier element, and overall performance of the rectenna. Based on the evaluation, rectenna with is most suitable use at frequency 2.45GHz to apply on body but there still some improvement that need to be investigate to increase the efficiency of the RF-to-DC conversion.

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