

Novel Rectifier Circuit For Energy Harvesting For High Output Voltage

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Abstract. A rectifier circuit is studied to harvest the ambient RF power at 2.45 GHz frequency. The circuit comprises a dual branch of Greinacher voltage doubler. This study addresses the problem of saturation due to diode threshold voltage. In fact, as the number of diodes used increases the reverse effect can be seen on the output voltage after a certain number of diodes. The results of the simulation of our rectifier show an output voltage of 2V at 2.45 GHz with 0 dBm input power.

Keywords; rectifier, energy harvesting, power combiner

1. Introduction

In the field of wireless communication and the Internet of Things (IoT), finding sustainable and efficient power sources is crucial. Rf energy harvesting has several applications across various industries such as Wireless Sensor Networks [1], Healthcare Devices [2], Wearable Electronics, Smart Agriculture. It offers the advantage of delivering a sustainable and potentially maintenance-free power source for low-power electronic devices. This study explores the use of an RF energy harvesting rectifier merged with two transmission lines to create a rectifying circuit with high output. RF energy harvesting involves capturing and rectifying RF signals, typically in the microwave frequency range, and converting them into DC electricity. However, power conversion can be inefficient when the input power is low, posing a significant challenge for energy harvesting rectifiers. This article explores the synergy between a rectifier and

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amplifying circuit, demonstrating their combined potential for generating high voltage outputs from harvested RF energy.

2. Rectifier analysis

The voltage doubler circuit shown in Fig 1 is a crucial component in RF energy harvesting rectifier circuits. It operates on the principle of capacitor charge and discharge and theoretically doubles the input voltage. The circuit is composed of diodes, capacitors, and resistors, making it a compact solution for converting low-voltage RF signals into higher DC voltages. [3] The analysis of voltage doublers involves understanding the interplay between components, capacitor charging cycles, and the resultant voltage multiplication. The input AC voltage is first rectified by a diode in a voltage doubler, resulting in a pulsating DC voltage. This pulsating DC voltage is then fed into a capacitor, which charges to the peak voltage of the rectified waveform. A second diode is used to direct the charged capacitor to a load during the opposite half-cycle of the input signal, effectively doubling the voltage across the load. This circuit works by alternately charging and discharging the capacitor, utilizing both halves of the input signal to achieve a voltage that is twice the peak amplitude of the original AC signal.

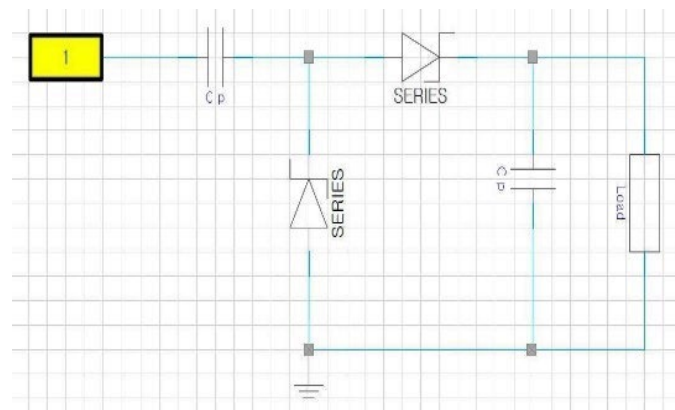


Figure 1. Voltage doubler circuit

The authors of [4] introduced a circuit that determines the limit of the number of stages by adding the output voltage of two branches of a voltage multiplier, as shown in Fig. 2. This approach improves power conversion efficiency. Their work inspired us to improve the rectifying circuit in order to produce higher voltage.

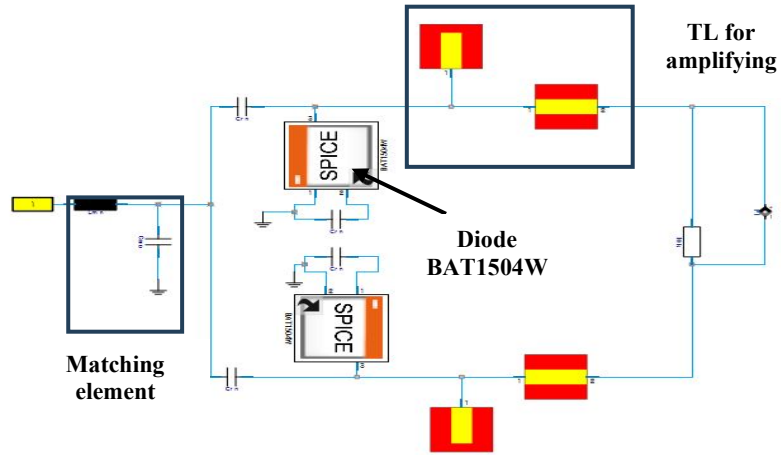


Figure 2. Proposed rectifier circuit

3. Results

The matching of our circuit is effective at 2.45 GHz with -30 dB as return loss as illustrated in Fig. 3. One drawback of our approach is that the matching is set on a narrow band. The graphs on Fig. 4 showed the results of the output voltage and power conversion for a load of 10 Kohm.

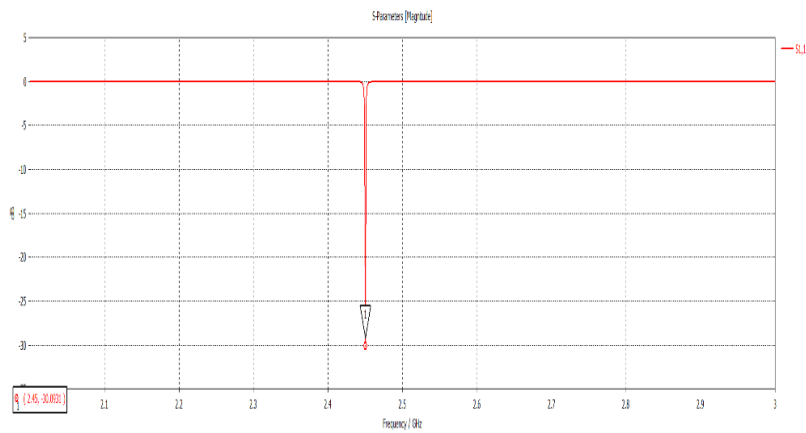


Figure 3. S11 of the rectifying circuit

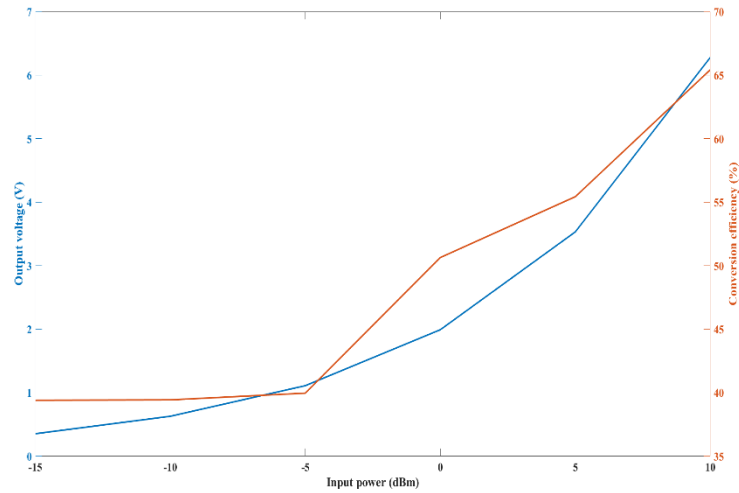


Figure 4. Output voltage and power conversion efficiency vs input power

References

- [1] P. S. Lakshmi, M. G. Jibukumar and V. S. Neenu, "Network lifetime enhancement of multi-hop wireless sensor network by RF energy harvesting," 2018 International Conference on Information Networking (ICOIN), Chiang Mai, Thailand, 2018, pp. 738-743
- [2] Y. Bouchoucha, D. Omri and T. Aguil, "Efficient ISM Band Rectenna for RF Energy Harvesting in IoT Healthcare Devices," 2023 International Conference on Communications, Computing, Cybersecurity, and Informatics (CCCI), Chongqing, China, 2023, pp. 1-8
- [3] Boylestad R. L. & Nashelsky L. (1978). Electronic devices and circuit theory (8th ed.). Prentice-Hall.
- [4] S. Fan et al., "A high-efficiency radio frequency rectifier-booster regulator for ambient WLAN energy harvesting applications," 2018 IEEE MTT-S International Wireless Symposium (IWS), Chengdu, China, 2018, pp. 1-3