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A Design of Self-biased Cross Coupled Rectifier with Integrated Dual Threshold Voltage for RF Energy Harvesting Application

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Abstract

RF signal is seemingly ubiquitous, these days. Majority of the devices that people are using today are continuously generating RF signals. Apparently, only a portion of these signals are being utilized and the greater part of it becomes wasted energy. However, these signals can be taken advantaged off. Scavenging techniques have raised to popularity because of its potential to convert ambient energy to usable electrical energy. It can be done by means of energy harvesting. Presented in this paper is a design of self-biased cross coupled rectifier that operates in Wi-Fi (2.4 GHz) frequency band which is suitable for Energy Harvesting Application. The design is implemented in 65nm CMOS Process Technology. It also introduces integrated dual threshold technique which further improved performance of the rectifier. At six (6) stages, the rectifier was able to extract 1.52 V usable DC voltage and attained a maximum power conversion efficiency (PCE) of 15.81%.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: Energy Harvesting; Rectifier; RF; WIFI

1. Introduction

Batteries have been the principal source of power for a lot of electronic devices nowadays. The invention of batteries made it possible for electronic devices to become portable and mobile. Despite having its capacity doubled and size

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reduced every couple of years or so, the technology of the battery advances at a much slower pace. While most electronics are geared towards miniaturization, batteries weren't able to adapt as fast. Present-day batteries are still limited to provide only up to a certain amount of energy density without having the danger of being explosive. Even with latest design and technology, the use of battery still place hard restrictions on products' usability. Moreover, the finite storage poses practicality issues due to cost of ownership. In the long run, battery replacement can have considerable impact in critical applications such as medical use, where constant replacement is impractical and has a high cost associated with maintenance. Batteries have outdone what it can offer to our fast-changing modern electronics. Despite the restrictions with using batteries, it is still possible to maintain the functionality by having an alternative source of energy that does not solely rely on it. This can be done by harvesting energy from ambient sources[1].

In the recent years, harvesting energy from ambient sources gained so much interest due to its massive potential. Energy harvesting, also known as energy scavenging, is the process of extracting ambient energy from various sources, such as vibration, light, or radio frequency, and convert it to a usable electrical energy. Using this technique presents a substantial potential to become a viable source to power low-powered devices and possibly eliminate the limitations of using only battery as its primary source.

Radio frequency harvesting is one of the most popular energy harvesting technique out there mainly because of its abundance. It harvests power from propagating RF signals which can be found basically everywhere especially in highly urbanize and heavily populated areas. RF sources are commonly generated by various wireless systems such as radio and television system, telemetry, mobile communication transmission, Wi-Fi base stations and other wireless devices. Despite that, energy that can be obtained from ambient sources are usually very limited. Hence, the challenge is to design a circuit that can optimally harvest a satisfying amount of usable energy[2].

2. Related Literature

Ideal RF to DC converter is the one that supplies the best direct current to the load: very low ripple, very high stability, large power conversion efficiency, and etc. However, a lot of constraints can be encountered in designing an RF to DC converter. Examples of these constraints are reverse leakage current, threshold voltage effect, large ripple, latch up, and etc. Various study has its own advantages and disadvantages. Based on review of related literature, the most efficient for a low voltage amplitude is the study of Ouda, et. al[6]. However, this design will only be efficient on a limited number of stages, which is not enough for battery charging, the main application the researchers focused on. Another study[3] is efficient in battery charging that could extract a large DC output voltage. However, this design has a lesser power conversion efficiency compared to others and efficient only on high voltage amplitude. In order to improve the designs aforementioned, the researchers modified a multistage configuration which is capable of charging low power devices operating on a 2.4GHz, a widely-used frequency band in RF energy. The modifications are stated in the proposed design section.

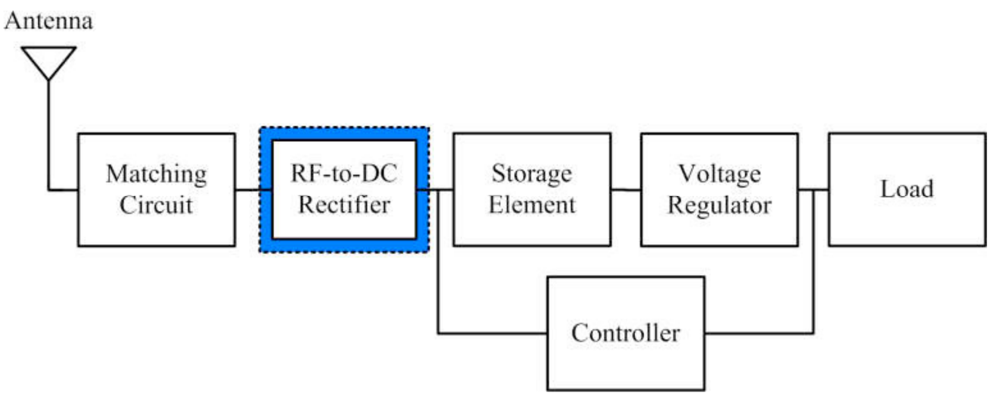

Fig. 1 Basic Energy Harvester Architecture