A High Sensitivity Wide Input Range CMOS RF Energy Harvesting Circuit

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Abstract This paper presents a 2.45 GHz high-sensitivity RF energy harvesting system. The input power range with high power convention efficiency (high-PCE) of the rectifier is extended by the both reconfigurable matching network and rectifier. The 2.45 GHz high-sensitivity wide input power range RF energy harvesting system includes a reconfigurable matching network, a reconfigurable rectifier and an efficiency optimization circuit. The efficiency optimization circuit produces 7-bit binary-weighted signal to optimize the both reconfigurable matching network and rectifier implemented in field-programmable gate array (FPGA). The reconfigurable rectifier is invented in 90 nm standard CMOS process. The simulation PCE of the proposed rectifier can be maintained about 20% with a 25 dB input range from -20 dBm to 5 dBm at 2.45 GHz. The sensitivity of the rectifier is -29 dBm at 1 V output voltage across a capacitive load.

Keyword CMOS Rectifier, RF Energy Harvesting, Wireless Power Transfer (WPT).

1. Introduction

Energy harvesting from natural environment is one of the most popular research trend in recent years. Through the energy harvesting from nature environment to instead of external batteries connection to a wired permanent power source. Multiple energy sources, such as sunlight, vibration, thermal and RF energy are potential candidates for various energy harvesting applications [1]. In recent years, lots of radio frequency communication systems are widely used in people's lives with the development of wireless communication more and more mature such as Wifi, LTE, GSM, etc. So using RF energy as a source of energy harvesting is a suitable choice. But there is a difficult problem that only Micro-Watts RF power receive [2]. For example, the terminal voltage of a 50Ω antenna with -20 dBm available power is only 63.24 mV, much too low to overcome the threshold voltage of a standard CMOS process which lies around 400 mV in 90 nm technology. Thus how to harvest and store these RF energy efficiently is a challenge [3].

Fig.1. shows the block diagram of Efficiently optimized far-field wireless power transfer (WPT) system. In this system, the RF energy source could be a cell phone, or a Wifi router. Then the RF power is received by the antenna from the energy harvester and sent to the reconfigurable matching network. The reconfigurable rectifier converts the RF power into DC power of the energy storage device and the load.

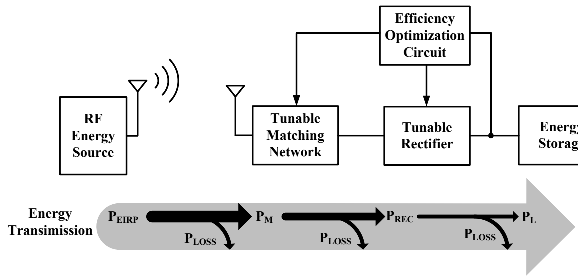

Fig.1. Efficiently optimized far-field WPT system.

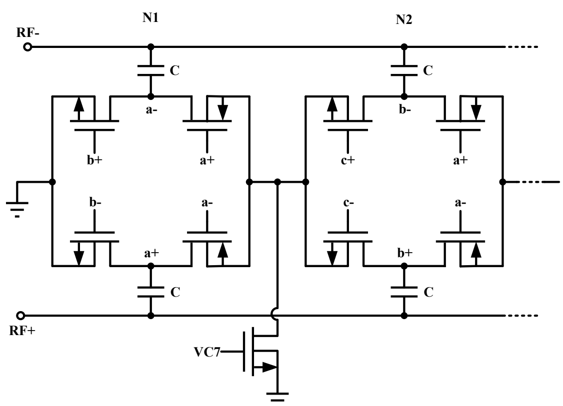

Fig.2. High sensitivity reconfigurable rectifier architecture diagram.

Adjusting the reconfigurable matching network and the reconfigurable rectifier through the efficiency optimization circuit, enables each WSN to have best efficiency when receiving different input power levels. However, in the far-field WPT system, the loss of each block junction and circuit will affect the efficiency of the WPT system, so the design must minimize the junction and circuit losses to achieve the highest efficiency of the entire WPT system.

In this paper, we propose an efficiency self-compensation and highly sensitive RF energy harvesting system in standard CMOS technology. Section II introduces the RF rectifier threshold compensation technology and introduces the proposed solution. The simulated performance of the RF energy harvester is discussed in Section III and conclusions are drawn in Section IV.

2. Circuit Design

This paper presents a 2.45 GHz high-sensitivity RF energy harvesting system with an efficiency optimization circuit in Fig.2.

This circuit uses a differential drive CMOS rectifier circuit to effectively reduce the reverse leakage current advantages, and adds multi-stage compensation features to effectively reduce the V_{TH} limit on the sensitivity of the circuit, and can be adjusted according to different input signals a suitable rectification series, and then a high-sensitivity wide input power optimized radio frequency harvesting circuit can be obtained.

3. Simulation Results

The proposed 2.45 GHz high-sensitivity wide input power range RF energy harvesting system was fabricated in TSMC 1P9M 90nm CMOS process. Layout of the chip is shown in Fig.3. The chip area is 1mm*0.7mm including the pads. The PCE of the system is shown in the Fig.4. at different input powers. Adjusted by efficiency optimization circuit to achieve the best efficiency at different input powers. (N is the number of rectifier)

4. CONCLUSION

A 2.45 GHz high-sensitivity wide input power range RF energy harvesting system was implemented by TSMC 90nm CMOS process. This system can be used for WSN/WBSN in IOT. The PCE of this system can be maintained about 20% with a 25 dB input range from -20 dBm to 5 dBm at 2.45 GHz in simulation. The sensitivity of the rectifier is -29 dBm at 1 V output voltage across a capacitive load.

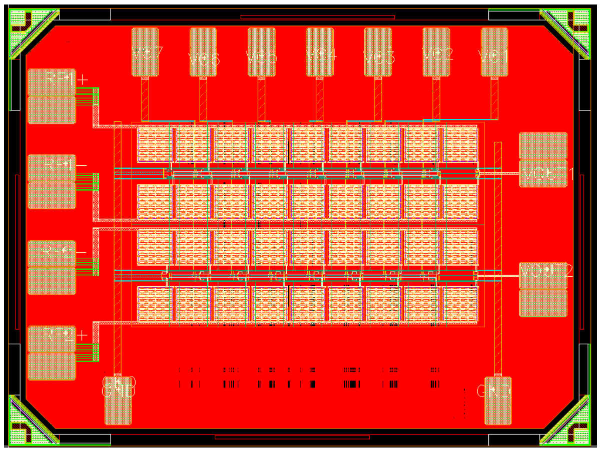

Fig.3. The layout of High Sensitivity Wide Input Range CMOS RF Energy Harvesting Circuit

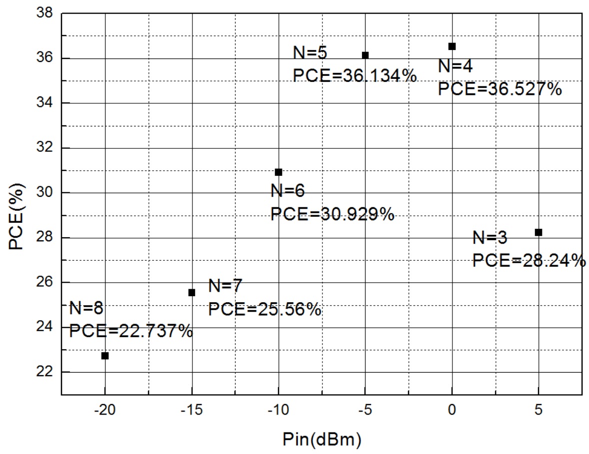

Fig.4. The PCE of High Sensitivity Wide Input Range CMOS RF Energy Harvesting Circuit with different inputs power.

5. ACKNOWOLEGMENT

Authors would like to thank Ministry of Science and Technology of Taiwan for supporting this research under Grant No. MOST 107-2221-E-032-047- and MOST 107-2321-B-001-038-.

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