A TG based 2-Stage High Frequency Rectifier with Current Booster Designed Using 45nm CMOS process for Low Power RF Energy Harvesting Application

MANASH PRATIM SARMA and KANDARPA KUMAR SARMA
Department of Electronics and Communication Engineering
Gauhati University, Assam, INDIA
mpsarma@gauhati.ac.in, kandarpaks@gauhati.ac.in

Abstract: - As the 5G communication technology is becoming a reality, the importance of energy harvesting to provide self-sustainability to the communication network is gaining more importance with reliable and faster data transfer capabilities. So, as achieving self-sustainability in terms of power is a significant goal, hence designing an energy harvesting system is an important aspect. The primary element of the energy harvesting system is the high frequency rectifier. But designing a rectifier at high frequency is very crucial. The main bottleneck of such a design is offered by the leakage in the CMOS device which in turn limits the percentage conversation efficiency (PCE) to be achieved at lower signal power. Also achieving a acceptable voltage and current at the output is essential. This paper presents a two stage high frequency rectifier design based on transmission gate (TG) with a current boosting mechanism for RF applications. This design achieves a maximum PCE to 90% at -2dBm in a double stage realization. This result is observed to be the highest efficiency in its class as compared to recently reported works. It performs well over a wide band of frequencies and is capable of working in commercially relevant frequency bands for mobile communication which is clearly depicted by the frequency response. Also this circuit uses optimal number of devices with total dynamic power dissipation of 4.6 μW.

Key-Words: - Energy Harvesting, Power Conversion Efficiency, Transmission Gate, CMOS, Current Booster, Radio Frequency (RF)

1 Introduction

With the advent of 5G communication, energy conservation and management is attaining more attention apart from the technological requirements of faster and reliable communication. Hence self-sustainability in all wireless networks is becoming an issue of potential importance. To address self-sustainability as well as virtual operation energy harvesting capability must be embedded into the network. As the energy harvesting capability of a network makes the life-time of the network augmented, it facilitates the installing of a network at any remote location and eliminates the requirement of an electrical power source. Hence energy harvesting is becoming an indispensable element in communications, medical as well as surveillance applications in the near future.[1][2]. Several natural and artificial sources can be well utilized for harvesting energy. As the nature of the sources are diversified and as there is a requirement to transfer the harvested energy from node to node, harvesting design has to be of different capabilities and efficiencies [3].

Design of a rectifier or charge pump is the core of the energy harvester design. There are different challenges in a rectifier designs. Some of them are high frequency compatibility, low power consumption, low area in silicon substrate etc. But to maximize the power conversion efficiency (PCE), the most important criteria which the designer must address to formulate an efficient design. Cross coupled bridge configuration with differential RF input can be designed which give low on state current and small leakage current and thereby offering better PCE[4]. Voltage doubler Ultra High Frequency (UHF) rectification unit is also designed with the technique of internal cancellation to achieve a zero-threshold transistor and thereby an accepted PCE is achieved with reduced area [5]. Dickson charge pump is one of the most widely used structure for this purpose and different modifications have been presented by several designers for specific applications and efficiencies. The Dickson charge pump has been modified to reduce the leakage current with linear regulator and thereby total power consumption can be reduced [6]. Rectifier based on improved Dickson charge pump

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