Proc. Annual Symposium on Research & Industrial Training, 02(2015) 57-61
Department of Electronics – Wayamba University of Sri Lanka

RADIO FREQUENCY ENERGY HARVESTING SYSTEM

S.U.Ekanayake*, W.A.S.Wijesinghe

Department of Electronics, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka
*upekha90@gmail.com**

ABSTRACT

Recent advances in ultra-low power wireless communications and energy-harvesting technologies have made self-sustainable devices feasible. Typically, the major concern for these devices is battery life and replacement. This paper presents a study of ambient RF energy harvesting technique, in which the radiated RF energy from ambient is extracted and converted into usable energy to power up devices. Applying energy harvesting techniques to devices can significantly extend battery life and sometimes even eliminate the need for a battery. The preliminary results indicate that the recovered energy is not sufficient to directly power devices but could be stored in a super-capacitor.

Keywords: harvesting energy, RF energy, Schottky diode, Voltage doubler

1. INTRODUCTION

Radio frequency energy is emitted by sources that generate high electromagnetic fields such as TV signals, wireless radio networks and cell phone towers, but through using a power generating circuit linked to a receiving antenna; this free flowing energy can be captured and converted into usable DC voltage. The circuit systems which receive the detected radio frequency from the antenna are made on a fraction of a micrometer scale but can convert the propagated electromagnetic waves to low voltage DC power at distances up to 100 meters [2].

We are being bombarded with energy waves every second of the day. Radio and television towers, satellites orbiting earth, and even the cellular phone antennas are constantly transmitting energy. What if there was a way we could harvest the energy that is being transmitted and use it as a source of power? If it could be possible to gather the energy and

store it, we could potentially use it to power other circuits. In the case of the cellular phone, this power could be used to recharge a battery that is constantly being depleted [6].

There are many complications to be dealt with. The first major obstacle is that it is not a trivial problem to capture energy from the air. We will use a concept called energy harvesting. Energy harvesting is the idea of gathering transmitted energy and either using it to power a circuit or storing it for later use. The concept needs an efficient antenna along with a circuit capable of converting alternating-current (AC) voltage to direct-current (DC) voltage [2]. The efficiency of an antenna is related to the shape and impedance of the antenna and the impedance of the circuit.

In this study it was attempted to design a feasible Radio Frequency Energy harvesting system.

2. EXPERIMENTAL

According to the Objective, the system shown in the figure 1 was designed.

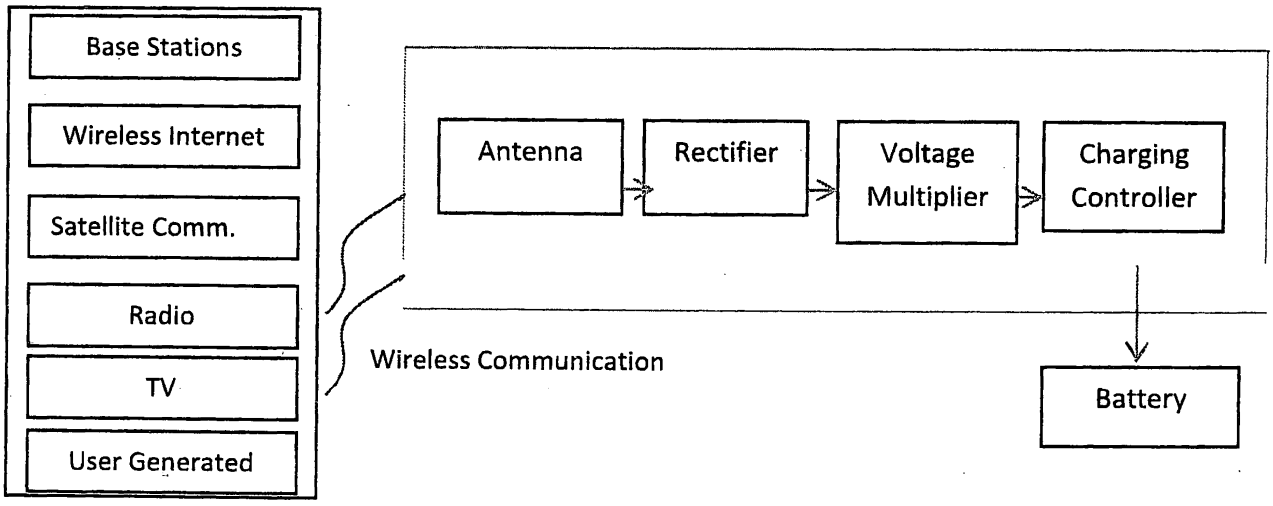

Figure 1: Basic block diagram

As for the Antenna widely available CDMA antenna and cellular antennas were used. For converting Radio frequency to DC, a rectifier circuit is used .A charge pump circuit such as a voltage doubler (multiplier) circuit can be used as the rectifier. A charge pump is a circuit

which with two diodes and two capacitors and gives the output as twice as the input, as shown in Figure 2 [3].

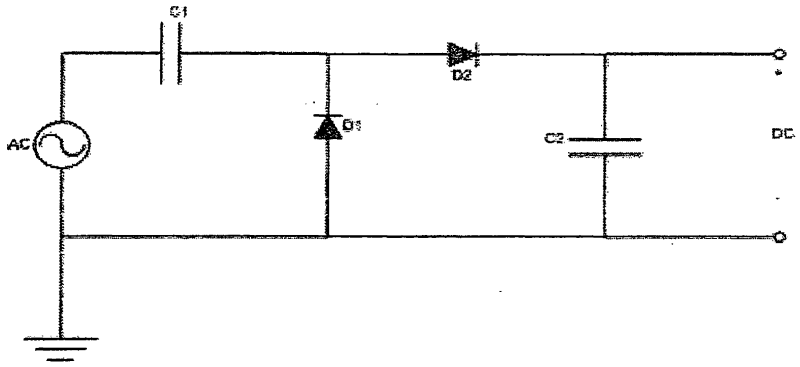

Figure 2: Single stage voltage multiplier circuit

It has been observed that the number of stages is essentially directly proportional to the amount of voltage obtained at the output of the system. Generally, the voltage of the output increases as the number of stages increases [1]. This is due to how the voltage multiplier works. In this paper a seven stage voltage multiplier circuit consisting of diodes and capacitors has been used for the rectifier and for the voltage multiplier as shown in Figure 3. Here the diode used is a schottky diode (HSMS 2820) because of its low forward voltage of 0.34V and high switching speed.

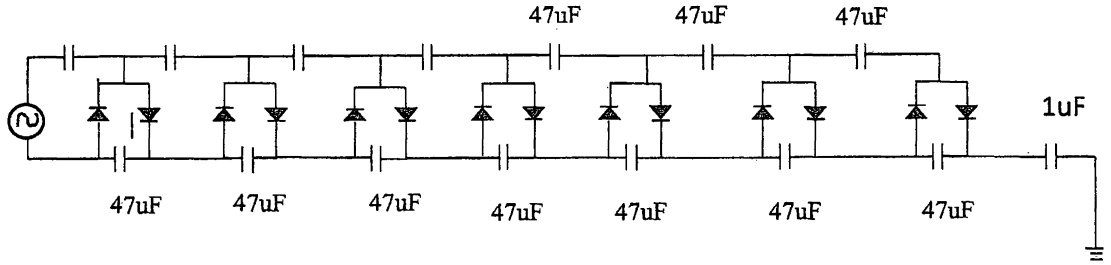

Figure 3: Seven stage voltage multiplier circuit using LTSpice

The capacitor values were changed and the output was observed. The capacitor value of 47uF gave the highest output, therefore 47uF was been chosen as the capacitor values. After all the simulations were run using the same capacitance for each stage, a simulation was run using varied stage capacitances between stages. The capacitance was varied in such a way that, from one stage to the next, the capacitance was halved. So, if the first stage was 47μF, the second was 22μF, third was 10μF, and so on. But, values were used so that they matched a component that was available in commercial components for testing. This meant that the 23.5μF capacitors were actually 22μF, and the 11μF capacitors were 10μF.

After studying the two simulations it was observed that the resulting output voltages were equivalent except for the rise time. The rise time for the circuit with different capacitor values for each stage was slower than the circuit which has the same capacitor values for each and every stage.

For the charging controller a supper capacitor of 1F has been used. . A super capacitor with 1F was selected as it has less self-discharge ability and low internal impedance.

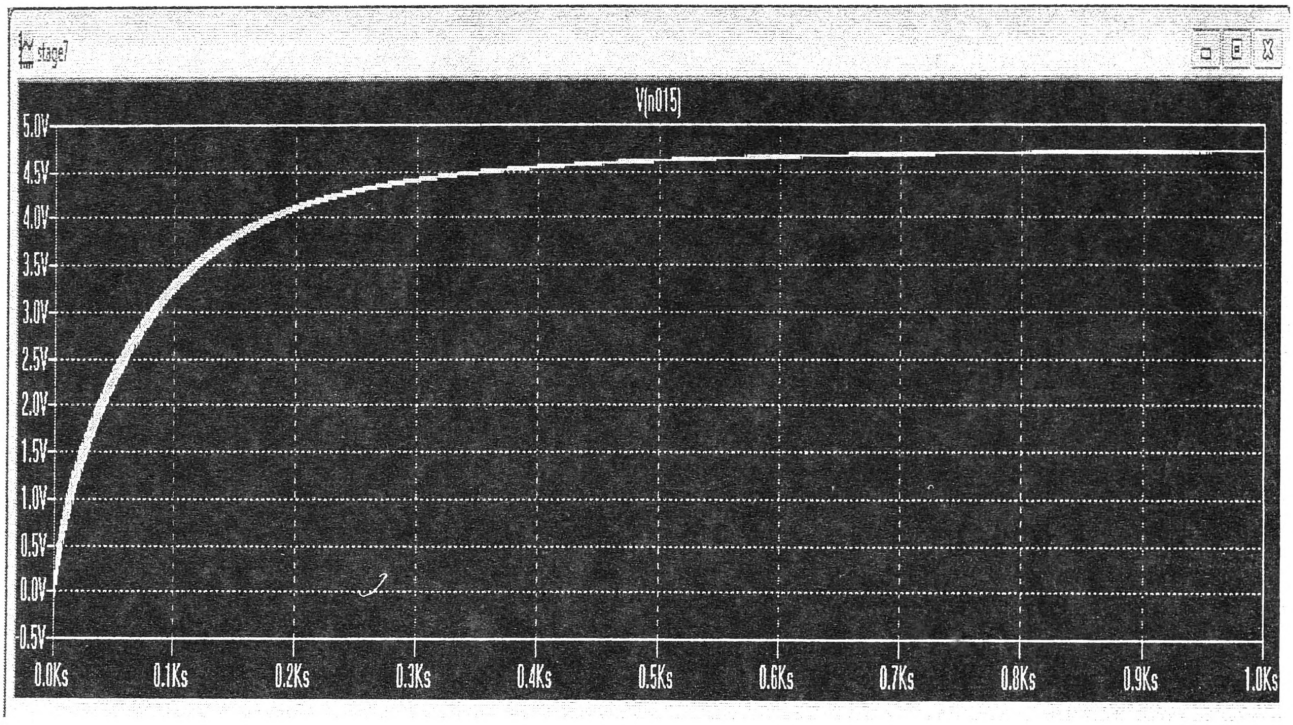

Figure 4: Simulation results for a seven stage voltage doubler circuit

3. RESULTS AND DISCUSSION

The final outcome of this research is a development of a DC current using freely available Radio Frequency signals. This is a very reliable system since the power source can be controlled and has minimum effects from weather. This is also a low cost, wire free device.

The DC output, harvested with the implemented system is very low. The level of RF energy and the mismatching of the antenna to rectifier are the causes of this low level DC output. The use of antenna arrays can increase the RF power and the DC output but for attended the significant DC level the size of the array must become very large.

4. CONCLUSION

The study and the implementation presented in this paper is an attempt on harvesting freely available Radio Frequency energy as a power option. It is found that we can harvest energy in micro watt range from ambient RF sources. Here the harvested power highly depends on the distance between the transmitter and RF harvesting system. By using an array of harvesting antennas we can harvest considerable amount of power.

ACKNOWLEDGEMENTS

Authors would like to to Mr. Nishan Wimaladasa who is the external supervisor of the Dialog Axiata PLC for his guidance and constant supervision. Further, thanks and appreciation also goes to Mr. G.C.Edirisooriya and Miss. K.U.Gedarakumbura.

REFERENCES

D. Bouchouicha, F. Dupont, M. Latrach, L.ventura, "Ambient RF Energy Harvesting", International Conference on Renewable Energies and Power Quality, Granada (Spain), 23th to 25th March, 2010.

[1]. James O, MC Spadden, Taewhan Yoo, Kai Chang, Theoretical and Experimental Investigation of Rectenna Element for Micro Wave Power Transmission ", IEEE Transactions On Microwave theory and Technique, Vol. 40, No. 12, December 1992.

[2]. Rakesh Kumar Yadav, Sushrut Das and R. L. Yadava, "Rectenna Design Development and Application" International Journal of Engineering Science and Technology, Vol. 3 No. 10 October 2011.

[3]. Daniel W. Harrist , wireless battery charging system using radio frequency energy harvesting, BS, University of Pittsburgh, 2001

[4]. Omar André Campana Escala, Study of the efficiency of rectifying antenna systems for electromagnetic energy harvesting