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RF Energy Harvesting

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Abstract : *Radio Frequency Energy Harvesting (RFEH) is a technology which enables wireless power delivery to multiple devices from a single energy source. The main components of this technology are the antenna and the rectifying circuitry that converts the RF signal into DC power. RF energy harvesting holds a bright future for generating a small amount of electrical power to the circuits in wireless communication electronics devices. Wireless power transmission was developing a thought nearly a century ago. Many achievements are made till date which have made power harvesting a reality and capable of providing alternative sources of energy. This includes a resonant voltage boosting network, which provides high bias from a small signal and a rectifier that produces DC voltage. The RFEH gives very good efficiency performance, if a single antenna is considered the maximum power delivered is generally not enough to power all the elements of a system. Since the energy harvesting circuits are designed to operate with very small number of voltages and currents, they are depends on the electrical technology for obtaining high efficiency*

Keywords **-** *Radio Frequency Energy Harvesting (RFEH), Voltage multiplier, Impedance Matching*

I. INTRODUCTION

The Radio Frequency Energy Harvesting (RFEH) is an important and very essential technology because of its advantages over the more popular harvesting technologies. In the past years the use of wireless devices is growing in many applications like mobile phones or sensor networks. This increase in wireless applications has generated an increasing use of batteries. The charging of multiple applications is easy because the user can do it easily, like for mobile phones. Collecting energy from radio waves and mobile applications is a feasible energy harvesting method, in which the power harvested will be present until the source signal is cancelled. The power can be transferred using inductive coupling at very short distances, inductive power transfer for mid-distances and RF power transfer for long distances. Wireless Power Transfer is a technology that can deliver power to one location to another locations, which are not possible for the conventional energy harvesting methods. There are several methods for applying wireless power supply. Near-field inductive coupling typically works on less than few centimeters and it's characterized by high efficiencies. Inductive coupling methods are not depending on radio propagation properties. They work on the distances much shorter than the wavelength of the energy source signal is done. Transmitters and receivers used in this technology are typically very large and energy can only be transferred over very short ranges where the distances are compared which are depends to the receiver and emitter physical sizes. The highest power efficiency available is only reached close to an optimal operating point.

II. LITERATURE REVIEW

Ambient RF Energy Harvesting, It was published in March 2010 and author name followed as D.BOUCHOUICHA. In this paper we have presented a study of feasibility to harvesting the ambient RF energy. The RF energy available in urban environment is very low. To scavenge a maximum of DC power we have presented a wideband system when able to deliver a DC power around 12.5pW. The rectenna has attracted great attention to recycle the ambient power radiated by wireless systems. Accordingly, the major goals of this thesis are on investigating a wide range of RF energy sources, different antenna types performance, designing novel rectennas for RF wireless energy harvesting and proposing novel ways of improving rectenna conversion efficiency for low input power density with the main goal to resolve the energy supply problems faced by the autonomous systems. [1]

Smart RF Energy Harvesting Communication, It was published in April 2015 and author name followed as Deepak Mishra. This article has explored various communication strategies that can complement RFH hardware advances toward realization of energy harvesting communication networks. The RF electromagnetic waves are harmless, abundant in space, and is able to penetrate through soft tissues. Those are properties that make RF electromagnetic waves an alternative source of energy to replace batteries in many applications. Particularly, RF power harvesting supports low power medical and healthcare devices and facilitates the development of WSNs and IoT by providing mobility of use. [2]

RF Energy harvesting system and circuit for mobile charging, It was published in January 2001 and author name followed as Anubbha Snair. This paper presents the CMOS based Villard voltage multiplier circuit to be compatible with CMOS processes. The circuit can be used in RF energy harvesting and RF power transmission systems. The circuit parameters are set according to design and input power range from -10dBm to 5dBm. The circuit shows improved output power than the traditional CMOS circuit. Higher performance can be achieved by implemented the circuit in low sub-micron manufacturing processes. Output voltage level can be increased using multiple stages of the multiplier circuit. The circuit can be used to capture the RF energy from a RF source by placing it adjacent to RF source (wireless routers, mobile handset etc.). The circuit can be implemented in mobile handsets, wireless sensor nodes etc. [3]

Efficiency in RF energy harvesting systems, It was published in August 2008 and author name followed as Mustafa Khanzis. In this study, not only theoretical knowledge but also practical application areas were highlighted. An RF energy harvesting system has been thoroughly reviewed in this paper. RF energy signals are ubiquitous and they have vital advantages for RF energy harvesting systems. Compared to the other energy sources such as solar, thermal gradients and mechanical vibrations, the power density of RF energy is relatively low but the amount of harvested energy is sufficient to power up some sensors or devices. In this study, not only theoretical knowledge but also practical application areas were highlighted. An RF energy harvesting system has been thoroughly reviewed in this paper. The blocks of an RF energy harvesting circuit, which are antenna and matching circuit, rectifier, voltage multiplier, and energy storage device or load blocks, have been investigated based on efficiency in detail. Antenna types and gains, impedance matching techniques, diode types, multiplier stages, supercapacitors, batteries and loads were explained separately. In order to obtain the maximum efficiency, optimization of each block in the energy harvesting circuit was discussed so that all the parameters affecting the efficiency were explained. [4]

Wireless Networks with RF Energy Harvesting: A Contemporary Survey, It was published in March 2013 and author name followed as Ping Wang. In this, they presented comprehensive survey on RF energy harvesting networks which conclude of architecture, applications and techniques. We presented the design considerations of an integration scheme of RF energy harvesting. In this scheme, a resonant tank is used to achieve sufficient voltage swing required to drive the following rectifier stage. The rectifier converts RF power into DC energy as stored charge in the capacitors. Simulation results showed that the proposed scheme was a promising solution for long distance self-power wireless application. [5]

III. METHODOLOGY

The key components of RFEH technology are the antenna and the rectifying circuitry that converts the RF signal into a DC signal (Figure 1). The load can be a DC energy storage device (Battery, capacitor, etc.) or, a directly powered device. In both cases, load parameters such as resistance and capacitance are often not constant. The requirements for a rectifier's characteristics would be defined by analyzing the signals at the antenna's output (or rectifier input) and the load's input. Analyzing the component's specifications of an RFEH system is an important aspect of its overall optimization process. Therefore, to analyze such a system in terms of power efficiency, two more components should be added to the diagram shown in figure – matching network and DC-to-DC charge pump. The importance of these two components will be demonstrated in illustrates the typical high-level configuration suitable for power efficiency analyses. It is important to highlight that, as in any other energy harvesting system, the goal is to maximize the rectified power available to the load terminals for a given incident RF signal power. This work focuses on optimizing the complete system, therefore all system blocks will be taken into account. Increasing the power conversion efficiency of RF-DC circuitry in RF energy harvesting circuits extends the range and reliability of autonomous networks. Multi-frequency waveforms are one technique that assists in overcoming the energy harvesting circuit diode voltage threshold, which limits the energy-conversion efficiency at low RF input powers typically encountered by sensors at the fringe of their coverage area. As shown in expression (1), each block contributes some conversion loss to the overall system efficiency.

$PDC = \eta M \eta P \eta CP \eta DC Pinc$ ---- (1)

where, PDC is output DC power, ηP is the parasitic and ηM is the matching efficiency, ηCP is the RF-DC conversion efficiency, ηDC is the DC-to-DC conversion efficiency, and Pinc is the incident RF power.

RF-DC conversion, has long been investigated for low frequency operation (AC-DC). In its simplest form, a series diode may be used to deliver the half of the alternating current to Resistance-Capacitance (RC) circuit where only the DC component appears across the load terminals, and the alternating content is filtered. Such a half-wave rectifying circuit is limited to 50% AC-to-DC power conversion for an ideal diode. At microwave frequencies, the rectifier circuit must be looked at as a resonant circuit, containing a nonlinear element which traps modes of the fundamental frequency and its harmonics. If the circuit is matched at each frequency, the rectifier acts as a full- wave rectifier.

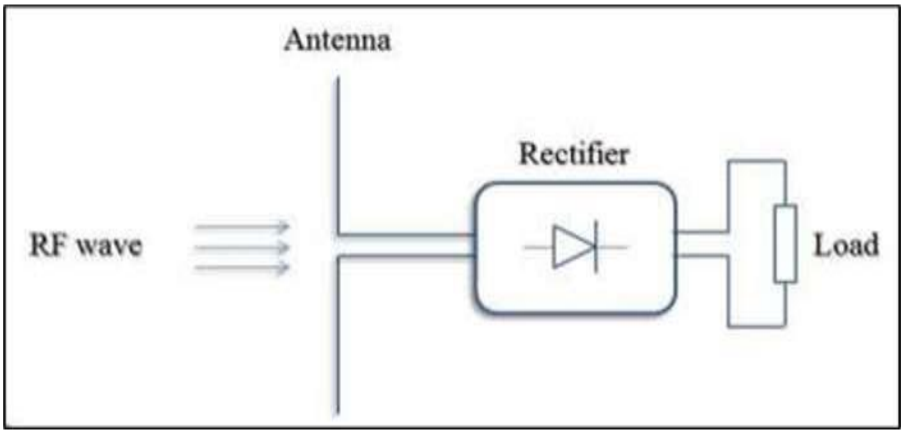

Figure.1: Block Diagram RF Energy Harvesting

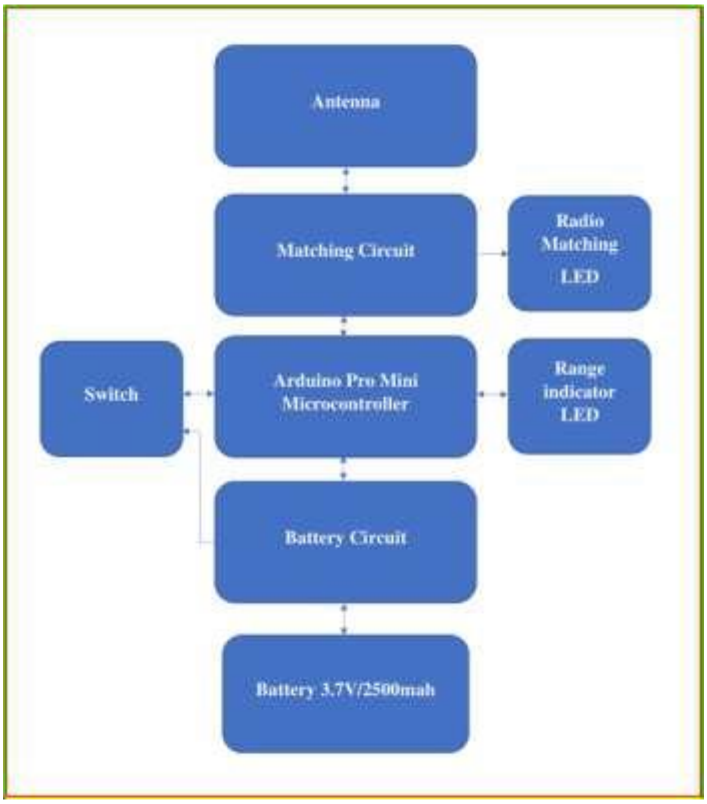

Figure. 2: Flowchart for RF Energy Harvesting

Figure 2 shows the flowchart of overall process. As we get RF waves as input through the antenna. This input gets transferred to our matching circuit. As soon as we get maximum energy the LED will glow. Then maximum signal is transferred from matching circuit to the Arduino which is working as when it's get energy it will glow first LED as the range increases another LED will also glow but, when the signal is very high that which harm us then the third LED will glow up with the buzzer. We used a battery which helps for matching circuit. For battery we construct a charging and discharging module which helps battery to overcharging and discharging. Module has indicator light to indicate the status of battery.

IV. RESULTS

According to three-phase cable structure and the theory of uniform transmission wires, it is known that whether or not current, there is distribution charge on the surface of electric conductor and parasitic capacitance between any two charged insulated conductors. Based on the theory, this paper proposes a new method. The signal is induced from the charge of conductor surface by sensors. Because there is less charge of conductor surface, the induced signal is week and needs to be enlarged, rectified and filtered to gain the perfect signal.

Figure 3: Construction of circuit

Figure 4: We get desired output

V. CONCLUSION

This project is the still working on RF power harvesting technology in recent years. This technology will play a key role in replacing batteries in near future. Practical applications of RF power harvesting are still under research and development. With the recent development of radio communications, a big number of wireless systems which transmit RF energy into the air but most of it has not been used. The antenna has attracted great attention to recycle the ambient power radiated by wireless systems. Accordingly, the major goals of this are on investigating a wide range of RF energy sources, different antenna types performance, designing rectennas for RF wireless energy harvesting and proposing different ways of improving rectenna conversion efficiency for low input power density with the main goal to reach high energy.

REFERENCES

[1] V. Raghunathan, a. Kansal, J. Hsu, J. Friedman, and M. Srivastava, “Design considerations for solar energy harvesting wireless embedded systems,”IPSN 2005. Fourth Int. Symp. Inf. Process. Sens. Networks, 2005., pp. 457– 462, 2005.

[2] B. P. D. Mitcheson, M. Ieee, E. M. Yeatman, S. M. Ieee, G. K. Rao, S. M. Ieee, A. S. Holmes, and T. C. Green, “Human and Machine Motion for Wireless Electronic Devices,” vol. 96, no. 9, pp. 1457–1486, 2008.

[3] S. Dalola, M. Ferrari, V. Ferrari, M. Guizzetti, D. Marioli, and a. Taroni, “Characterization of Thermoelectric Modules for Powering Aut onomousSensors,” IEEE Trans. Instrum. Meas., vol. 58, no. 1, pp. 99–107, Jan. 2009.

[4] M. A. Green, “Thin-film solar cells: Review of materials, technologies and commercial status,” in Journal of Materials Science: Materials in Electronics, 2007, vol. 18, no. SUPPL. 1, pp. 15–19.

[5] R. Kappel, W. Pachler, M. Auer, W. Pribyl, G. Hofer, and G. Holweg, “Using thermoelectric energy harvesting to power a self-sustaining temperature sensor in body area networks,” Proc. IEEE Int. Conf. Ind. Technol., pp. 787–792, 2013.

[6] A. Khaligh, P. Zeng, and C. Zheng, “Kinetic Energy Harvesting Using Piezoelectric and Electromagnetic Technologies,” Ind. Electron. IEEE Trans., vol. 57, no. 3, pp. 850–860, 2010.

[7] “Circuit Design Tools & Calculators | Design Center | Analog Devices,” Analog Devices. [Online]. Available: http://www.analog.com/en/design-center/design-tools-and-calculators.html#LTspice. [Accessed:10-Sep-2018].

[8] J. O. McSpadden and J. C. Mankins, “Space solar power programs and microwave wireless power transmission technology,” IEEE Microw. Mag., vol. 3, no. 4, pp. 46–57, 2002.

[9] Y. S. Hwang and H. C. Lin, “A new CMOS analog front end for RFID tags,” IEEE Trans. Ind. Electron., vol. 56, no. 7, pp. 2299–2307, 2009.

[10] Z. Zhong-Qiu, Z. Peng, X. Shou-tao, and W. Xindong, IEEE, arXiv:1807.05511v2 [cs,CV], 16 Apr 2019.

[11] J. B. Goodenough, “US Patent,” 4302518, 1980.

[12] B. Thide, Electromagnetic Field Theory. 2000.