Energy Harvesting and Management from Ambient RF Radiation

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***Abstract*—**The energy harvesting from external ambient sources e.g. wind, solar, vibration, heat, Radio Frequency (RF) are emerging as promising alternative to existing energy resources. In recent years, the huge proliferation of RF/mobile communication in developing country like India has made RF energy harvesting as an attractive solution to the dramatically increasing energy needs. Energy Harvesting is the process of electronically capturing and accumulating energy from a variety of energy sources deemed wasted or otherwise said to be unusable for any practical purpose. More often than not, these residual energies are released into the environment as wasted potential energy sources. Wireless sensors and the potential of energy harvesting to provide power for the life of these devices. The greatest potential, however, lies in a new class of devices that will be battery-free and thus enable applications that would have been prohibitively expensive due to the maintenance cost of eventual and repeated battery replacement. This project deals with the harvesting of energy based on the RF source here the power is transfer from the antenna, there by using the impedance matching is done. Hence this project deals with the harvesting of energy based on the RF source here the power is transfer from the antenna, there by using the impedance matching is done so that to gain more power from tower and the rectifier circuit convert an incoming RF signal to DC signal that is fed into battery and an efficient rectification improves the output power.

***Keywords*—**Antenna; DC Signal; Energy Harvesting; Impedance Matching; Radio Frequency.

***Abbreviations*—**Analog-to-Digital Converter (ADC); Radio Frequency (RF); Super Capacitor (SC).

I. INTRODUCTION

THE major issue concerning the scientist nowadays is the excessive use of natural gas and petroleum. It has been predicted that these resources will be exhausted in the next two or three decades. The overconsumption of petroleum and natural gas has also caused adverse effect on the environment. The scientists are trying hard to find the alternate sources of renewable energies and reduce the dependence on petroleum and natural gas. One such alternative is "radio frequencies". The radio frequencies are electric energies that transmit through the air by ionizing the medium on its paths. The radio frequency energy can be easily found in surroundings as it is used widely by many applications like television broadcasting, telecommunication, microwave etc. It is ubiquitous and free and highly efficient.

The main aim of this paper is to investigate the levels of power that can be harvested from the surrounding and to achieve energy that is sufficient to charge low power electronic circuit. Through a power generating circuit linked to a receiving antenna this free flowing energy can be captured, harvested and converted into usable DC voltage to power up small devices [Chowdary & Chatterjee, 1].

II. EXISTING SYSTEM

In the existing system, energy harvesting is derived alternate source of energy from various external sources. The harvesting unit mainly consists of an antenna to grab the RF energy and a rectifier for conversion of RF energy to DC power. In this existing method for energy harvesting we use source such as the thermal energy, solar energy, and kinetic energy but such energy are deposited or stored in miniature electronic and electrical devices which are usually positioned in energy source points. The phenomenon of energy harvesting furnishes very less amount of energy [Kotani et al., 4].

2.1. Disadvantage of Existing Method

RF energy harvester is positioned for optimal directional

- High power consumption.
- Alignment and polarization with respect to the transmitting antenna
- Low power density (environment)
- Low efficiency (RF2RF)
- High efficiency conversion - complicated system
- Limitation of ISM band

III. PROPOSED SYSTEM

This Proposed System is a wireless charging by using RF energy harvesting. This project deals with the harvesting of energy based on the RF source here the power is transfer from the antenna, there by using the impedance matching is done so that to gain more power from tower and the rectifier circuit convert an incoming RF signal to dc signal that is fed into battery an efficient rectification improves the output power. Here the radiation from the receiving antenna in the form of RF energy can be converted to dc form by using a rectifier circuit at an optimum operating point and rectified output sent to storage unit for an optimum power level optimized output sent to charge a device [Mazzilli et al., 3].

3.1. Advantages of Proposed System

- Free energy
- Wireless energy transfer
- Portable devices
- Easier than plugging into a power cable
- Corrosion does not occur when exposed to atmosphere
- Safe for medical implants for embedded medical devices
- Allows recharging through skin rather than having wires penetrate
- It does not require wire for charging

IV. BLOCK DIAGRAM

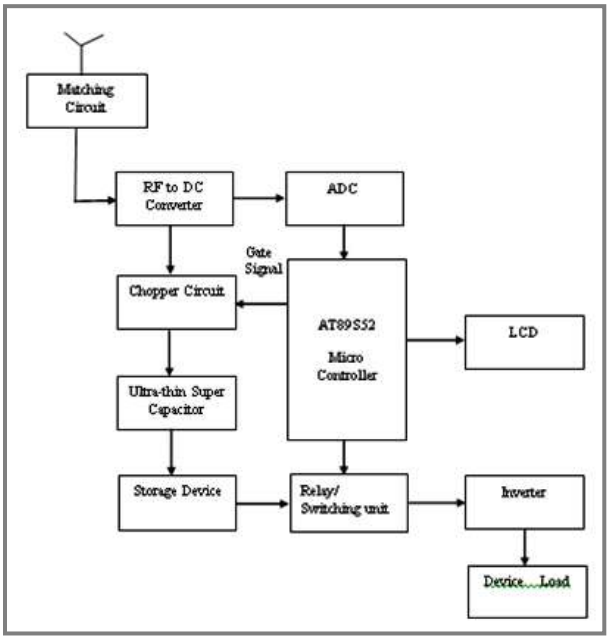

Figure 1: Block Diagram

4.1. Block Descriptions

4.1.1. Matching Circuit

Source and load circuit impedance. In electronics, impedance matching is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load.

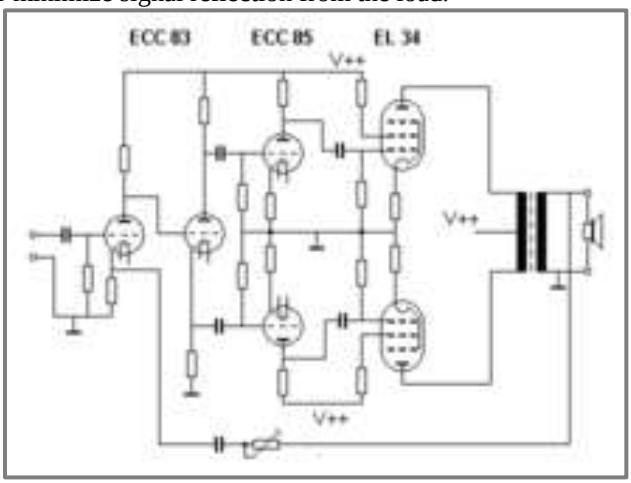

Figure 2: Matching Circuit

4.1.2. Chopper Circuit

In electronics, a chopper circuit is used to refer to numerous types of electronic switching devices and circuits used in power control and signal applications. A chopper is a device that converts fixed DC input to a variable DC output voltage directly.

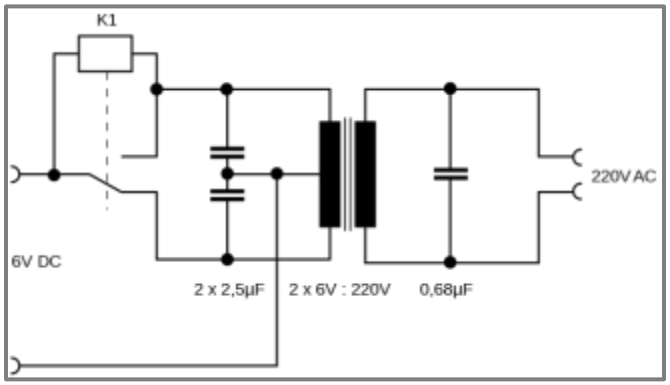

Figure 3: Chopper Circuit

4.1.3. Analog To Digital Converter

The input to an analog-to-digital converter (ADC) consists of a voltage that varies among a theoretically infinite number of values. Examples are sine waves, the waveforms representing human speech, and the signals from a conventional television camera. The output of the ADC, in contrast, has defined levels or states.

4.1.4. AT89S52 Microcontroller

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory [Stoopman et al., 2]. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the Indus-try-standard 80C51 instruction set and pin out. The Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

Figure 4: AT89S52 Microcontroller

A Super Capacitor (SC) (also Electric Double-Layer Capacitor (EDLC), also called super cap, ultra capacitor or Gold cap) is a high-capacity capacitor with capacitance values much higher than other capacitors (but lower voltage limits) that bridge the gap between electrolytic capacitors and rechargeable batteries. They typically store 10 to 100 times more energy per unit volume or mass than electrolytic capacitors, can accept and deliver charge much faster than batteries, and tolerate many more charge and discharge cycles than rechargeable batteries.

Super capacitors are used in applications requiring many rapid charge/discharge cycles rather than long term compact energy storage: within cars, buses, trains, cranes and elevators, where they are used for regenerative braking, short-term energy storage or burst-mode power delivery. Smaller units are used as memory backup for Static Random-Access Memory (SRAM).

4.1.5. LCD

LCD (Liquid Crystal Display) is the technology used for displays in notebook and other smaller computers. Like Light-Emitting Diode (LED) and gas-plasma technologies, LCDs allow displays to be much thinner than Cathode Ray Tube (CRT) technology.

4.1.6. RELAY

Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. As relay diagrams show, when a relay contact is Normally Open (NO), there is an open contact when the relay is not energized.

4.2. Implementation and Output

The working and testing was carried out in two parts first wired and then wireless. Each is explained below in detail along with the results observed:

Wired:

The passive receiver circuit consists of 3 stage voltage doublers and temperature Sensor AD590 as a load.

The voltage doubler consists of SM components: Diode SMS7630, a zero bias schottky detector diode from skyworks and SM Capacitor which works in high frequency range.

A Marconi instruments transmitter which works in the frequency range from 9KHz to 2.5GHz with maximum power level 25dBm is used.

Frequency versus Voltage and Current Table for wiredmoduleat15dBm. V and I measured at output of 3rd stage of Voltage Multiplier.

Table 1: Frequency Response of Wired Module

Frequency(MHz)	Voltage(V)	Current(mA)
750	1.76	1.45
780	2.03	1.37
800	1.66	1.12
840	3.128	2.4
850	3.03	1.98
900	2.7	2.72
950	2.21	1.83
1000	2.18	1.61
1050	1.33	1.43
1100	1.62	1.66
1150	2.28	1.34
1200	1.83	1.219
1300	1.15	0.59

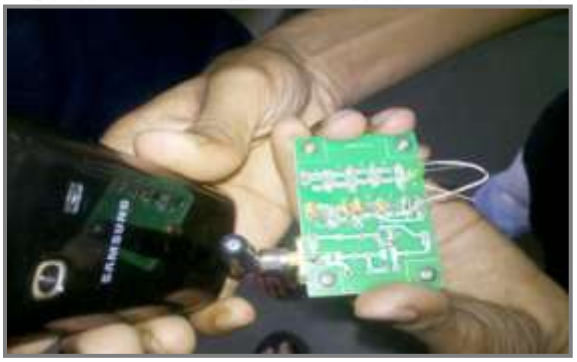

Figure 5: Implementation

V. CONCLUSION

This report presents the design of RF Energy Harvesting System. The potential utilization of RF signals for DC power is experimentally investigated. Several steps are taken to achieve this methodology. A thorough study of various topologies of Impedance Matching, Antennas, Voltage Multipliers have been discussed. Based on that, we have chosen effective topology for each block. As a result of this overview, m derived Band pass filter is designed to give a constant impedance over the selected frequency range and Series RLC is chosen for one particular frequency. The Microstrip Antenna having gain 7dB to 9 dB for a square patch and an omni - directional monopole antenna suits our requirement. Based on measurements and simulations, it can be concluded that it is possible to use radiated, off-air RF signals as a source for energy harvesting. Even though the output powers of such harvester are expectedly relatively low, it can be sufficient for running low consumption sensors and switches. Improvements on efficiency of the RF signal harvesting is important. This will enable more current to be re-cycled and operate low-power circuits. The possibility of using this harvester in energizing sensor networks appears to be the most practical use at the moment. Finally, we have presented a new technology that can revolutionize the way we charge our numerous mobile devices. It helps portability of devices without carrying chargers around.

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