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 potential of energy harvesting 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. 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 signaling 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. We can apply this setup to various useful applications.*

Keywords- RF Energy, AC Voltage, DC Voltage, Impedance matching, Rectifier, ADC and Gate Signal

I. INTRODUCTION

An embedded system has specific requirements and performs pre-defined tasks, unlike a general-purpose personal computer. An embedded system is a computer- controlled system. The core of any embedded system is a microprocessor, programmed to perform a few tasks (often just one task). Embedded systems are often designed for mass production. By using embedded system, we are going to design our project. 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. For energy harvesting we use source such as the thermal energy, solar energy, and kinetic energy but such energy are 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.

II. RELATED WORKS

K.K.A.Devi, NorashidahMd.Din, C.C.K. Chakrabarty, S.Sadasivamin, 2012, "**Design of an RF-DC Conversion Circuit For Energy Harvesting".**

The function of this voltage multiplier circuit is to convert the RF energy signal into DC voltage that can be used to energize the low power electronic devices. The design was based on the Villard voltage multiplier circuit. A4-stage Schottky diode voltage multiplier circuit was designed, modeled, simulated, fabricated and tested for its performance . Multisim was used for the modeling and simulation work. The input for the voltage multiplier module was fed through an efficient matching network from an RF energy harvesting antenna which is designed at 377Ω impedance .For a received signal of -27dBm(1.99)μW at the antenna modules produce a DC output voltage of 2.1V across 100KΩ load.

Triet Le, KartiMayaram, *Fellow, IEEE*, and Terri Fiez, *Fellow,* IEEE JOURNAL OF SOLID-STATE CIRCUITS,VOL.43,NO.5,MAY2008. "Efficient Far-Field Radio Frequency Energy Harvesting for Passively Powered Sensor Networks"

Passive rectifier circuits are designed in a 0.25 μm CMOS technology using floating gate transistors as rectifying diodes. The 36-stage rectifier can rectify input voltages as low as 50 mV with a voltage gain of 6.4 and operates with

received power as low as 5.5 µW (- 22.6 dBm). Optimized for far field, the circuit operates at a distance of 44 m from a 4W EIRP source. The high voltage range achieved at low load current make it ideal for use in passively powered sensor networks.

Marko Ninic, RadivojeDuric, SERBIAN JOURNAL OF ELECTRICAL ENGINEERING,Vol.14, No.1, February 2017, 133-148, "A Novel High Efficiency CMOS RF/DC Power Harvester Based on Constant ON/OFF Time Buck Controller for 60GHz Frequency Band".

A novel 60 GHZ RF/DC power harvesting is presented. The system consists of RF to DC rectifier and a DC/DC Buck converter based on constant ON/OFF time(COOT)control. The peak efficiency of the rectifier obtained with the extracted parasitics for the output power of 1mW is about 20%.In order to keep the output voltage of the system to 1.2V,the COOT control in the Buck converter is used. COOT control has much better efficiency at low output powers compared to the PWM systems. For correct operation of the COOT control, auxiliary sub-blocks ; a low power high speed comparator, a hysteresis comparator, and a high speed voltage reference are designed and presented. The maximum switching frequency in the buck converter is about 100MHZ and the whole control system has very low static power consumption.

Muh-Dey Wei, Ya-Ting Chang, Defu Wang, Chao-Hsiung Tseng and Renato Negra, "Balance RF Rectifier for energy recovery with minimized input impedance variation".

A balanced RF rectifier is proposed to replace terminations in microwave circuits and thus to recycle the otherwise dissipated power in resistances.it minimizes the variation of input impedance of the rectification circuitry.the proposed balanced rectifier thus significantly improves s11 over existing rectifiers and is therefore suitable for replacing resistive terminations.

Kavurikasi Annapurna devi, Norashidah Md.din ,Chandan Kumar Chakrabartyapril 4,2012."Optimization of the Voltage Doubler Stages in an RF-DC Conversion Module For Energy Harvesting".

Optimization of the voltage doubler stages in an rf-dc convertor module for energy harvesting of 900Mhz. This design is based on the villard voltage doubler. Multisim is used for simulation and modeling work for an equivalent signal of about -40dbm ,the circuit can produce 3mv across 100kohm load. The results also show there is a multiplication factor of 22 at 0 dBm and produces DC voltage of 5.0v .this voltages are used to replace the batteries that are used to power up the low power sensors.

III. EXPERIMENTAL SETUP

This Proposed System is an wireless charging 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. Fig 1 shows the block diagram of the proposed system. The main blocks involved in our system are

1. Micro Controller (At89s52)
2. Analog To Digital Converter
3. Bridge rectifier
4. Relay Unit
5. Voltage regulator
6. UART
7. LCD
8. Power supply

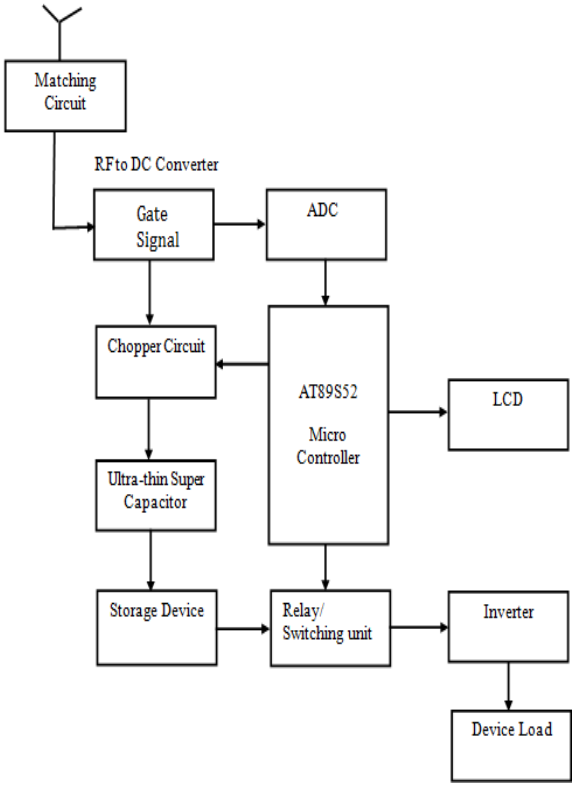

Fig.1 Block Diagram

1. Micro controller

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. 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 on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory pro-grammer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM con-tents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

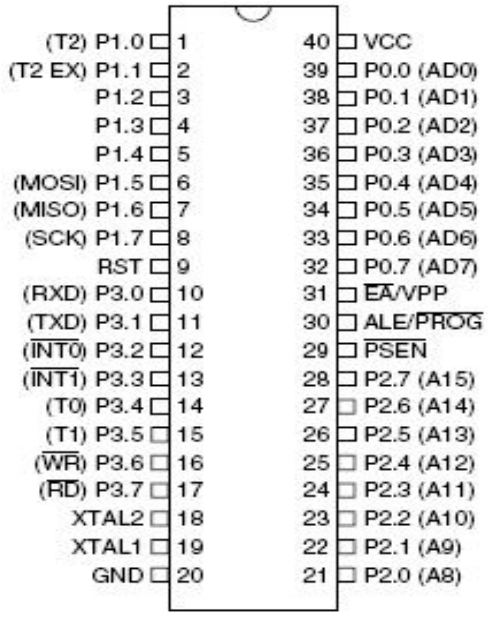

Fig.2 Pin diagram of 89s52

2. ADC 0808/0809

The ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique.

The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals.

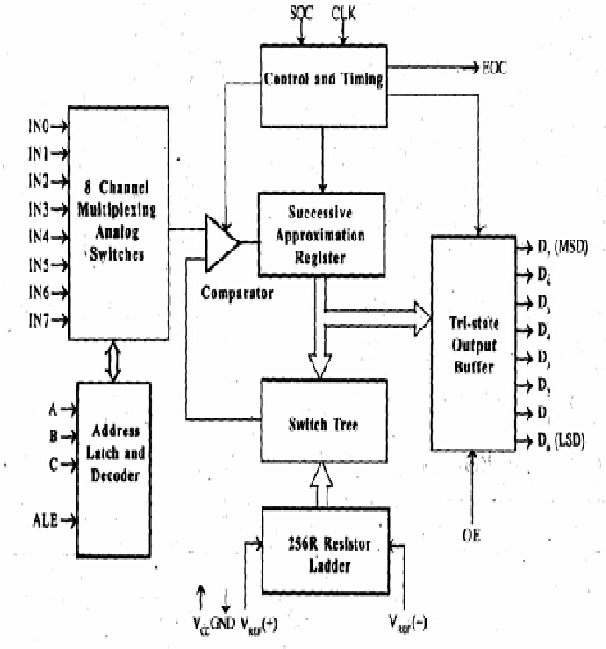

Fig.3 Block Diagram of ADC 0809

The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs. The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power.

4. Bridge Rectifier

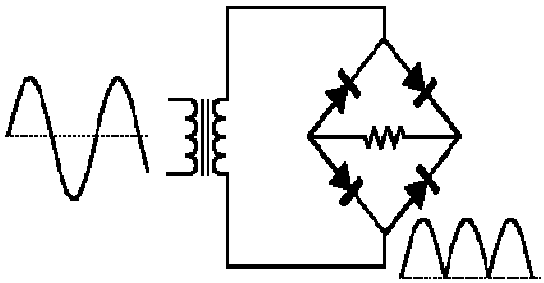

Fig.4 Circuit of bridge rectifier

A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.

5. Relay

A relay is an **electrically operated switch**. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are **double throw** (**changeover**) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

6. Voltage Regulator

LM7805: 3-Terminal 1A Positive Voltage Regulator

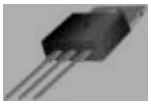

Fig.5 Diagram of voltage regulator

Features:

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18 and 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Description:

The KA78XX/KA78XXA series of three-terminal positive regulator are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents. The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic.

7. UART

A Universal Asynchronous Receiver Transmitter is usually an individual (or part of an) integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. A UART is used to convert the transmitted information between its sequential and parallel form at each end of the link. Each UART contains a shift register which is the fundamental method of conversion between serial and parallel forms.

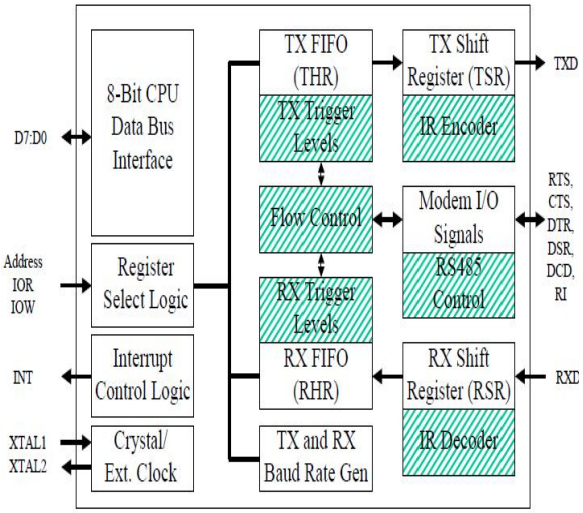

Fig.6 Block Diagram of UART

8. LCD

Liquid Crystal Displays are most commonly used because of their advantages over other display technologies. They are thin and flat and consume very small amount of power compared to LED displays and cathode ray tubes (CRTs). LCDs use ambient light to illuminate the display making them more suitable for outdoor use.

9. Power Supply

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

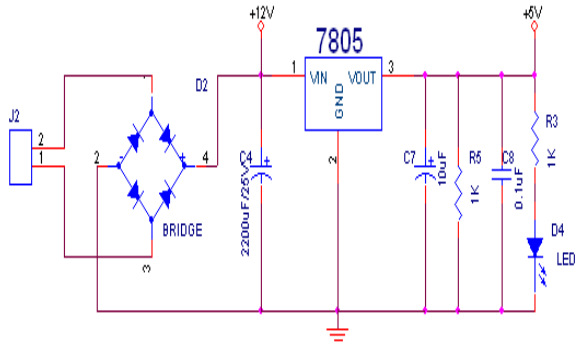

Fig.7 Power supply

A 230v, 50Hz Single phase AC power supply is given to a step down transformer to get 12v supply. This voltage is converted to DC voltage using a Bridge Rectifier. The converted pulsating DC voltage is filtered by a 2200uf capacitor and then given to 7805 voltage regulator to obtain constant 5v supply. This 5v supply is given to all the components in the circuit. A RC time constant circuit is added to discharge all the capacitors quickly. To ensure the power supply a LED is connected for indication purpose.

IV. SOFTWARE ANALYSIS

The programs of the microcontroller have been written in Embedded C language and were compiled using KEIL, a compiler used for microcontroller programming. The communication between PC and the microcontroller was established MAX 232 standard and those programs were also done in C language. The following programs are used at various stages for the mentioned functions Serial communication in this program, the various special function registers of the microcontroller are set such that they can send and receive data from the PC. This program uses the serial library to communicate with the ports.

V. ADVANTAGES

- Free energy and 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

VI. APPLICATIONS

- Health Monitor
- Security Monitor
- Home appliance

VII. CONCLUSION

By using a linearized model of a rectifier, a complete description of an RF harvester can be made without compromise. This analysis is confirmed by measured results and HB computer aided simulations for different RF harvester circuit topologies. It is shown that an RF harvester can be optimized using the equations from a linearized RF harvester model. This provides a unique advantage over computer aided simulations which gives little insight into the design trade-off and the effect of the component parameters on the performance of the harvester. The theory presented in this paper could be used for broad design considerations before a specific RF harvester circuit topology is adapted. The theory has been proved by using low cost off-the-shelf components. However the model is equally applicable to custom made designs based on complementary metal-oxide-semiconductor (CMOS) process.

VIII. ACKNOWLEDGEMENT

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