

RF Energy Harvesting in Health Monitoring System

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ABSTRACT: Notable advancements in technology and the use of low-powered sensors in industrial applications have made it an obligation to establish wireless solutions for low powered applications. One of the current trending technology for replacing batteries and other exhaustible resources is to make use of the ambient energy available in the environment which is possible by implementing RF energy harvesting. RF energy harvesting captures ambient RF energy through the means of an antenna and transforms this energy to useable DC power. The purpose of this paper is to design the processing circuitry required to convert a received RF signal into useable DC power, with the ability to power up low- powered sensors and applications. The design carried out here is to use the RF energy signal captured by the antenna that specifically aims at the license free ISM band of 868Mhz. The design consists of RF-DC converter block, which focuses on converting the RF signal into useable DC power, this can achieved by the usage of a voltage multiplier circuit. The design and implementation is explained in this paper.

KEYWORDS: Radio frequency, Energy harvesting, Low power technology.

I. INTRODUCTION

The ability to communicate using wireless channels and non-usage of batteries has made working in harsh and unfavourable conditions more easier. One more vital reason to get rid of these batteries is the motive to become eco-friendly. The chemicals used in the batteries are hazardous to both environment and human health. With the concept of energy harvesting it is now possible to use sensors without batteries which was once even difficult to imagine. There is a wide assortment of surrounding vitality sources and comparing Energy Harvesting Technologies with various conditions of specialized development accessible. The degree of deliverable vitality from every innovation changes additionally emphatically from the low small-scale Watt system to significantly increase digits in the milli-Watt run for gadget sizes important to this work. However, this assortment is a chance to locate the appropriate Energy Harvesting Technology for IoT-gadgets and the utilization cases which they spread. Some Energy Harvesting Technologies effectively offer the essential force yield to drive IoT gadgets. Be that as it may, usage isn't clear. The vitality gatherer must comply with the utilization case and the relating accessible encompassing vitality, subjects which must be viewed as when beginning to structure a gadget. The main section of the energy harvesting is to efficiently convert RF signals into DC signals using voltage doubler circuit. The proposed venture works in 865-867 MHz permit excluded recurrence extend accessible in India for input radio force levels of $\leq 25/14$ mW/dBm. The proposed venture works in 433-434 MHz or 865-867 MHz permit excluded recurrence extend accessible in India for input radio force levels of $\leq 25/14$ mW/dBm.

II. RELATED WORK

Energy harvesting strategies are very good deal crucial in one's life as they're gambling as an options for the batteries in lots of wireless systems. One of the most latest harvesting approach is the usage of RF energy (Radio Frequency) which is freely available and are released by various means. RF harvesting is a energy conversion method which uses energy contained in an electromagnetic waves is transformed into useful electrical power (DC current). Major reasons to use this harvesting strategies are disposal and refinement of battery wastes as it is an essential and critical complication. Majority of batteries results in landfills, causes main to the pollutants of land and water underneath. As because these harvesting strategies will not give rise or generate to any type of wastes so it's far a clean energy supply and underwater programs where batteries are not realistic to apply.



A realistic IoT application powered actually with the aid of RF-based totally wireless electricity transfer had developed and discussed the methodology for an application and also plan of action of developing and evaluating components of a solution. A brief look at on the selection of the required components is considered based at the specific utility. The efficiency of the technique is increased in many ways.[1] In any electronic gadget one’s always the power consumption ought to be lesser or equal to the energy manufacturing in any system. Power management is largely used to increase the efficiency and robustness of the systems. Some of the power control strategies such as power grating, maximum power tracking etc., Wireless power transfer method also helps to extend and realise smart power management techniques to optimize the solutions.[2]

Smart health applications are notably used in the present generation. A wireless patient monitoring device is invented, which measures the heart rate and body temperature of the patient and keeps a tracking and sends to the monitoring android based interface. A warning signal is made such that people near patient can hear in case of emergency.[3] Wearable technology and gadgets along with cloud computing and IoT is implemented as a result a new and scalable health monitoring tool is designed. Finally they decided wearable sensors along with IoT intelligence offer various choices for operation and storing of the information.[5]

RF power harvesting design that is developed with the usage of filters, voltage doubler circuit and boost converters and examined a harvester circuit for selected 2.4 GHz range and a capacitor on the output is used as accumulator. The major issues came about are boost converters as input is very low and leakage currents of the capacitor is seen.[4] A method is made to design the circuit that uses various multiple frequencies of RF cellular and ISM bands. An adjustable circuit for harvesting for diverse frequencies is developed and showed a battery free communication system with the usage of ambient RF indicators as only the source of power. Finally their results revealed more than 45% strength conversion efficiency for their application.[7] One greater model is proposed a way of deriving output characteristics specifically current and voltage. This design consists of seven stages Dickson voltage multiplier rectifier which uses Schottky diode (HSMS 285C) is made use and corresponding equations are calculated. This model proposed an accurate method of deriving output characteristics.[8]

A multistage Dickson voltage multiplier i.e., two to six stages may be designed easily and also different matching circuits such as L- matching, T- matching and Pi- matching circuits are studied as they're essential for complete energy tranfer and its related equations are calculated. Schottky diodes(HSMS-2852 and HSMS- 2822) are used for the designing of DVM to estimate the performance. Simulation consequences arrived are of high performance and excessive output DC voltage received for DVM with matching circuit.[9] Another design they used a patch antenna and a seven stages RF-DC conversion circuit is designed and simulated. But drawback was to improve the performance via using boost converter[10]. For this we can also use multistage rectifiers and quadrupler. The energy acquired is very much less and the further process is to design DC-DC converter to boost the voltage for a preferred output that may be sufficient to powerup a sensor in order that it could be economically viable.[11].

III. METHODOLOGY

- 1.The first stage in a RF energy harvesting circuit is a receiving antenna with the ability to capture ambient RF signals.
- 2.The next stage in the RF energy harvesting system is rectification as the obtained energy from the antenna is in Ac. It is converted into DC by rectifier.
- 3.The last stage of the circuit is switch mode power conversion, which refers to DC-to-DC conversion block of the voltage which is optional can be used when the output of second stage is not sufficient for target application.

Table. 1: Antenna specifications

| PARTICULARS | VALUES |
|-----------------------|----------|
| Frequency Range (MHz) | 868 |
| Impedance(ohm) | 50 |
| Gain(dBi) | 5.0 |
| Polarization | Vertical |
| Radiation | Omni |
| VSWR | <1.7 |
| Maximum input power | 50 |

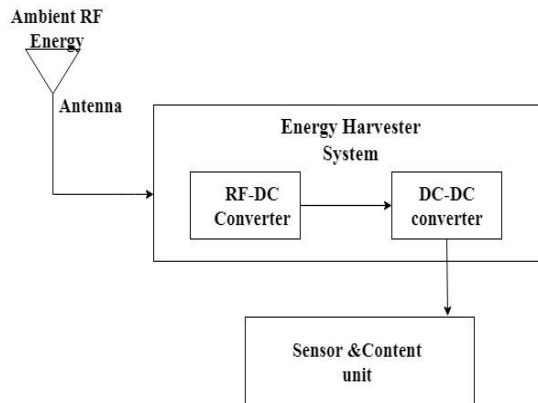


Fig 1. Block diagram of RF Energy Harvesting circuit

3.1. SELECTION OF FREQUENCY BAND

With the enormous scope of surrounding RF frequencies, most of circuit structures focus on a solitary frequency band, as this outcomes in an increasingly plausible antenna design. The radio frequency band envelops signals from 3kHz to 300GHz. The frequency range selected for the proposed method is 865-867 Mhz. AS it is one of the license free RF band available in India and also enables transferring of maximum amount of energy. Also, the introduced outcomes uncover the measure of vitality accessible satisfies the sum required for controlling the objective application. In this way we can conclude that the target application is achievable. Also, the perfect balance between long range and low power utilization can be obtained using 865-867 Mhz band.

3.2. ANTENNA FOR RF ENERGY HARVESTING

In the first stage RF energy harvesting circuit captures the ambient RF signals using suitable antenna. The antenna used in proposed methodology is 868 MHz RightAngle-210mm LoRA, LORAWAN Antenna with the following specifications:



Fig 2. 868 MHz RightAngle-210mm LoRA, LORAWAN Antenna

But earlier it has been discussed about the license free bands in India and the selected band was 865-867Mhz. However, there is a silver lining with the 868 MHz Lora band. Similar to other frequency bands 868 MHz Lora band also consists of 8 channels. These eight channels are spread over frequencies starting at 865.20 MHz and ending at 868 MHz. Hence it is clear that large portion of the 868 MHz Lora frequency channels are in the License free 865-867 MHz band that is among the eight channels seven channels are in the License free band in India. So it is good to go with 868 MHz Lora antenna in India.

3.3. RF-DC CONVERTER

The output signal from the first stage will be a low-voltage RF signal. This RF signal must be changed over to a DC voltage so as to create a useable DC power. A rectifier is an electrical circuit with the capacity to change over an AC signal to a DC signal. One common method for signal rectification used in RF energy harvesting is the voltage doubler which consists of diodes and capacitors, as this circuit not only rectifies applied input signal but also amplifies it.

Diodes are considered as the basic component of any circuit that performs rectification. The diode is the part that confines the frequency that can be rectified maximum also decides the rectified DC output level. The diode selected is Schottky diode as, Schottky diodes contain a quick metal-semiconductor junction with a forward voltage drop of under 0.15V contrasted with a semiconductor-semiconductor junction. The various RF low voltage Schottky diodes such as BAT63, various series of HSMS were studied and HSMS-2860 Schottky diode was selected because of its low voltage and current ratings and low loss. Due to non-availability of these diode initially BAT63 which has low threshold was used for the simulation using Multisim software where a seven stage RF-DC conversion circuit is designed to obtain optimal voltage and current at the output of the RF-DC converter as shown in below figure.

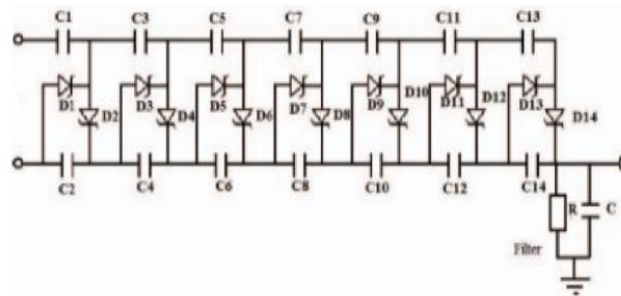


Fig 3. RF-DC conversion circuit

IV. EXPERIMENTAL RESULTS

We used the LimeSDR to test and determine the precise frequency among the RF band in order that we recognize the precise frequency where can we achieve the maximum output. We had simulated and received that 2.4G and additionally 865-867MHz frequency may be used among the free ISM bands.

We decided on a LORAWAN antenna of 868MHz. The output from the antenna using LimeSDR is shown below:

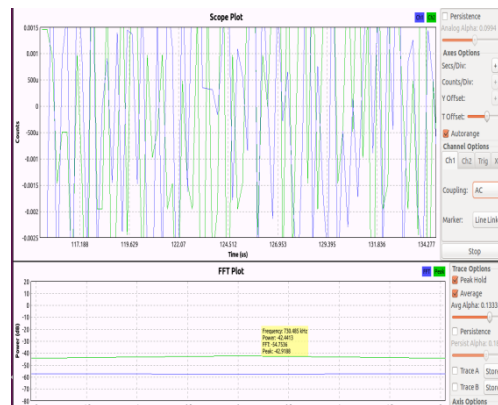


Fig 4. Output plot from the LimeSDR kit

The output strength obtained was -70 dB and 600 micro volts varying Vrms voltage. Since the received output is no longer sufficient for our actual-time application. We have designed a voltage multiplier circuit that consists of capacitors and diodes.

So from the above LimeSDR we come to know the output power estimation but it is very less. Since the acquired output is no longer enough for our real-time utility. We have designed a voltage multiplier circuit that includes capacitors and diodes.

This circuit receives AC power that's of very less voltage at the input, that is then converted into DC voltage and multiplied depending upon the variety of levels within the circuit. The diode used is BAT63 and capacitors of 1nF is selected through trial and error technique. The voltage will increase because the number of stages within the circuit is increased we can use a maximum of 7 degrees in any of the application.

We used Multisim Software for the simulation of the Voltage doubler circuit and simply had an ordeal of estimating our output before the hardware implementation. We are using a 7 stage Voltage doubler circuit consisting of BAT63schottky diodes and capacitors of 1nF.

The simulation output of the voltage doubler circuit from the Multisim software is shown below. The expected output was 43m Vrms for the selected frequency but the obtained output from the doubler circuit was 355.141mV as constant DC voltage after 30 minutes of time delay. The output for this circuit is supposed to be a constant DC voltage but there is a ripple in the waveform due to the AC components. Hence, a passive resistor and capacitor filter was used. The basic property of a capacitor is to prevent any sudden change in voltage. A capacitor does this by absorbing the excess of voltage and supplying it whenever it is required. This accounts for several charging and discharging cycles occurring in the capacitor. Thus this leads to clearing off the repulse by making the output waveform quite smooth. When tested with this filter the output took more time to become stable and only for 1kilo-ohm and 100 pF values of resistor and capacitor, the value stabilized immediately. But the output voltage was very low compared to the input voltage.

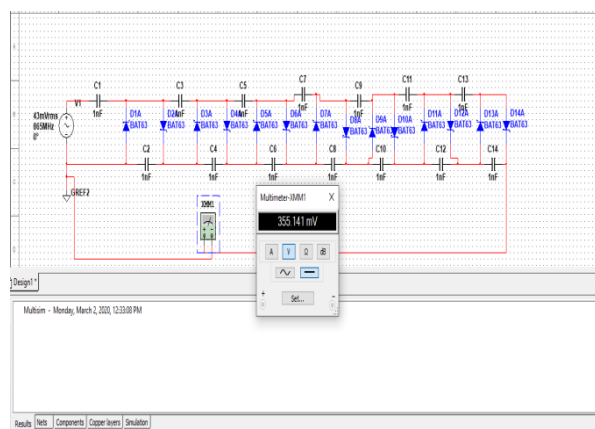


Fig 5. Simulation results of an Voltage doubler circuit

V. CONCLUSION

The proposed project functions in 865-867 Mhz license free frequency band available in India for input radio power levels of $\leq 25/14$ mW/dBm. Even though the losses are still quite high, they may enable particular real-time M-IOT applications. The approach enables replacing a battery with a solution enabling a sensor to get powered with the energy available around it. This enables for the battery-free sensor applications, which are more ecologically friendly and can enjoy more simple service and maintenance. RF energy harvesting provides effective solutions for IOT, medical, industrial and various smart home applications. RF energy harvesting can be used in various low power applications. RF energy is transmitted from a lot of external sources and devices in our surrounding at any given moment. There is lot of advantages if we could harvest this energy from surrounding sources. However, it is difficult to use such an harvesting system in mechanical systems as RF sources surrounding machines are often not desired the energy obtained from such sources is very limited. With the advancement of RF energy harvesting there is lot of potential for RF energy harvesting in applications such as IOT, home automation, smart sensor technology which operates at micro watt input, wire-free charging of electronic devices and wireless sensors such as proximity sensors, temperature sensors and humidity sensors. By using RF energy harvesting technology as an alternative power source our future mobile phones will be capable of operating. Also this technology will be used by Wearable devices and medical sensors as power source. RF energy harvesting also supports Low-power medical applications and health care devices as RF waves are harmless, RF waves are abundant in surrounding and mainly they are able to penetrate through soft tissues. Due to the wire-free transmission and compact size the power from the RF energy harvesting system can be used by enhanced security devices that makes use of smart sensor technology.

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