Efficient Utilization of RF and Optical Energy Harvesting For Low and Medium Power Applications

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Abstract-In this paper, the new design is introduced that is used to improve the efficiency of RF energy having as a two power level of 300mw &above by utilizing the radio frequency range from 10 KHz to 20 GHz the additional requirements responsible for this high efficiency are super heterodyne receivers (which acts as frequency up and frequency down converter), carbonnano tube optical retina analog with usual requirement for RF harvesting i.e., rectenna and power management circuits. This Proposed novel design is implemented and simulated using MATLAB software.

I. INTRODUCTION

Finite dielectric batteries ensourastry companies and researchers to core up with new ideas and technologies to drive wireless mobile devices for an enhanced period of time batteries add to size and their disavowal add to environmental pollution for mobile and miniature .Electronic devices a promising solution is available in capturing and storing the energy from external ambient sources a technology known as energy harvesting other names of this type of technology are power harvesting energy scavenging and force energy which are derived from renewable energy in recent years the use of wireless devices is growing in many applications like mobile phones and sensor networks this increase in wireless applications has generated an increasing use of batteries many research teams are working on extending the battery life by reducing the consumption of the devices other teams have chosen to recycle ambient energy like in micro electro mechanical systems (MEMS)[1-3]. The charging of mobile devices is convenient because the user can do it easily like for mobile phones but for other applications like wireless sensor nodes which are located in different to access environments the chirrs of the batteries remain a major problem the research of RF energy harvesting provides reasonable techniques of over these problems. The rectification of microwave signals to DC power has been proposed and reserved in the cortex of high power charging the DC power depends on the available RF power the choice of an antenna and frequency band an energy harvesting technique using electromagnetic energy specifically radios frequency is the flows of this paper.

II. PROPOSED METHOD

In the proposed method, optical rectenna and super heterodyne mixer are added to the regular RF energy harvesting method as shown in the Fig 1, to improve the efficiency of energy harvesting.

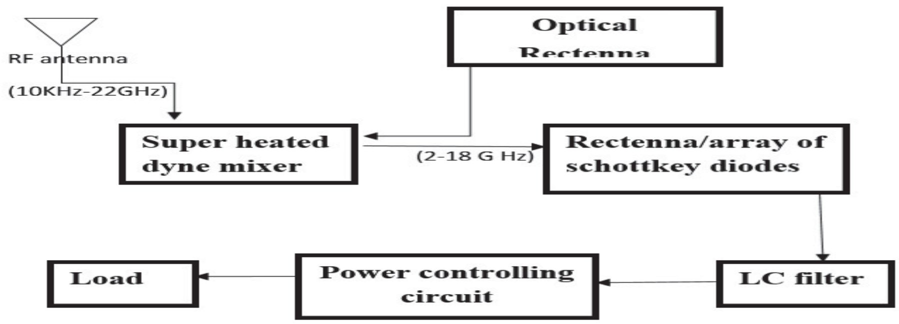

FIG 1; Block diagram of proposed method

A.Optical Rectenna:

An optical rectenna in FIG 1 is a device that directly converts free propagating electromagnetic waves at optical frequencies to direct current was first proposed over 40 years ago yet this concept has not been demonstrated experimentally due to fabrication challenges at the nani scope realising an optical rectenna requires that an antenna be coupled to a diode that operates on the order 1Phz (switching speed on the order of its) diode operating at these frequencies are feasible if there capacitance is on the order of a few attofarads but they remain extremely difficult to fabricate and to reliably couple to a nano scale antenna an optical rectenna by engineering metal insulator metal tunnel diode with a junction capacitance of-2af at the tip of vertically aligned multiple carbon nanotubes which act as the antenna upon irradiation with visible and infrared light we measure a dc open circuit voltage and a short circuit current that appear to be due to a rectification process in contrast to recent reports of photo detection based on hot eletron decay in a plasmonic nano scale antenna a cohered elliptical antenna field appears to be rectified directly in our devices consistent with rectenna theory finally power.[4]

B .Up/Down Converter:

FIG 2 shows, the single-ended double sideband (DSB) mixer was introduced.For this type of mixer the upper and lower sidebands “fold” in the down conversion process and are present at the intermediate frequency (IF) output.This technique allows amplification and filtering of the detected signal at an intermediate frequency (IF) where electronic circuits work well. In contrast to the super heterodyne receiver, early radio pioneers like Marconi employed direct down-conversion to baseband techniques without IF conversion.

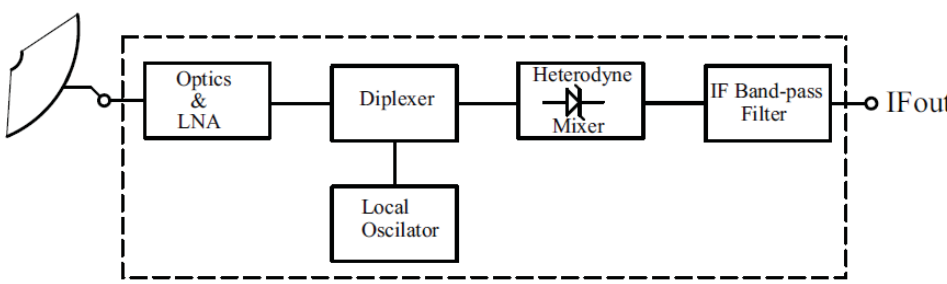

FIG 2; Block diagram of Super heterodyne Receiver

The classical example of this is the AM crystal radio. In practice, due to poor frequency selectivity and front-end filtering, this technique results in a poor signal-to-noise ratio (SNR) at the detector output. These problems were often exacerbated by the inadequate front-end and mixer components at the time. As an interesting side note, modern AM and FM integrated circuits avoid the standard 10.7 MHz and 455 KHz IF frequencies and process the information at a frequency closer to baseband where integrated circuit (op-amps) work well. This avoids the use of large inductors and capacitors needed at the forth mentioned IF frequencies. The elegance of the single-ended mixer is its simplicity. It is no accident that during WW II, microwave diode mixers experienced, as part of the radar technology development effort, a tremendous boost in frequency range, sensitivity, and reliability. From this early beginning, it has proven very difficult to extend heterodyne principles to sub millimeter and terahertz frequencies. It was not until the mid-seventies that technology allowed the first (InSb) hot electron bolometer and SIS mixers. These mixers were single-ended (1 diode) DSB. Even today the majority of sub millimeter and terahertz receivers are constructed this way. Simplicity comes however with some undesirable properties. The mixer has, for example, poor RF/LO isolation and no immunity to intermodulation products or amplitude fluctuations of the local oscillator source. For some applications an additional disadvantage is that both the signal and image sidebands are present at the IF output.

C.Rectenna:

A rectenna is a rectifying antenna,a special type of antenna that is used to convert electromagnetic energy into direct current (DC) electricity. They are used in wireless power transmission systems that transmit power by radio waves. A simple rectenna element consists of a dipole antenna with an RF diode connected across the dipole elements. The diode rectifies the A[C current induced in the antenna by the microwaves, to produce DC power, which powers a load connected across the diode. The rectenna consists of a highly efficient photonic-band-gap (PBG) structure, a microstrip lowpass filter (LPF) with defected ground structure (DGS) circuitry, and a Schottky diode. To evaluate the rectenna, it was fabricated on a low-cost FR-4 printed-circuit-board (PCB) material with relative dielectric constant (ε_r) of 4.4 in the z-direction at 10 GHz and thickness of 1 mm. As will be shown, the rectenna achieves RF-to-DC conversion efficiency of 63% when processing received power of +18 dBm at 2.45 GHz.[4]Studies of wireless transmissions, and methods for preserving and conserving the power from those transmissions, have continued since the first wireless power transmissions (WPTs) by Nikola Tesla in 1899. Rectennas have been of interest for their capabilities to convert RF energy to DC power, and provide the opportunities to "reuse" some of this transmitted wireless power. In recent years, microstrip circuit technology has been widely used for the development of receiving rectifier antennas, with RF-to-DC conversion efficiency representing one of the most important parameters of any rectenna design.A rectenna is an antenna with additional components, including a LPF and a rectifying circuit. The rectenna receives microwave energy from the antenna.[4-6] A Schottky rectifier diode converts the received RF energy to DC power.[7-9] The amount of power that can be transmitted is limited, and the amount of RF/microwave power is reduced from the source through attenuation, mainly due to free-space signal path loss. For use in portable devices which, in generally, usually have small dimensions, an effective rectenna design should also have small dimensions.In order to achieve higher-order harmonic rejection of unwanted signals, the rectenna design employs a miniature microstrip LPF with DGS.[10,11] The simple DGS is applicable on 50-Ω feeder lines to achieve the requires lowpass filtering performance. The LPF with DGS can suppress and isolate second- and third-order harmonic signals from the rectifying circuitry, allowing the rectenna to achieve its target high

D. Power Management Circuit:

` The purpose of the power management circuit is to act as a buffer between the rectenna power source and the energy storage device to act as an ideal buffer in the harvesting application, the converter must perform three functions:- 1) create at its input port the optimal impedance match to maximize the rectenna efficiency ηR over the full range of incident power densities.2) Transfer the harvested energy with ideally no loss to the energy storage element over the full range of rectenna output voltages Vdc and energy storage charge states.3) monitor the energy storage and provide charge control and protection as appropriate for the energy storage used (battery or capacitor). Since the efficiency of the rectenna depends on the matching behavior of the converter, and the efficiency of the converter depends on the operating conditions of the rectenna.where PR,dc max is the rectenna dc output power with an optimal load. The filter integrated in the rectenna creates a dc port and reduces the rectenna model from the perspective of the power converter to a Thevenin equivalent, and the rectenna output impedance reduces to an equivalent resistance. Thus, the optimal load to the rectenna is a dc resistance, apparent in the measurement results, where the load value at maximum rectified power is about 300 W over a wide range of incident power densities.[5-8] The converter is modeled with an input port that emulates a resistor Rem and an output port that transfers all of the power from the input port to the energy storage device, shown as a battery model. This behavior is similar to that commonly used in power converters for alternating current/direct current (ac–dc) power conversion with power factor correction (PFC), although the PFC goal and the high voltage and power levels in those applications are entirely different from the harvesting application.The challenge in the low-power harvesting application is to perform the behavior of with minimal control circuit overhead so that the control losses can be kept small when compared to the power being processed. This rules out many of the advanced control circuits and techniques commonly applied at higher power levels. A boost converter is selected to provide the required step up from typical rectenna voltages of tens to hundreds of mill volts to typical battery voltages, from 2 to 4 V.

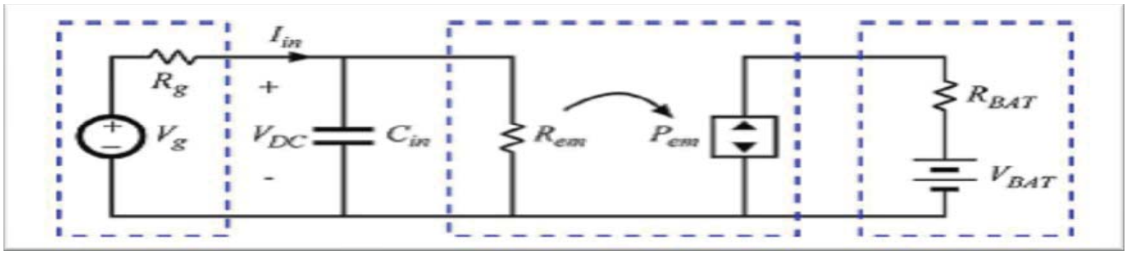

FIG 3; Power management circuit

III. RESULTS AND DISCUSSIONS

To inspect the level of available RF powers of air signals, which is variable and dependent on the surroundings, some environmental measurements were conducted. For this purpose, a spectrum analyzer (Rohde & Schwarz FSH3) and a monopole GSM antenna were used. Figure 4 illustrates the efficiency of RF signals existing in frequency range of 100 MHz to 20GHz.

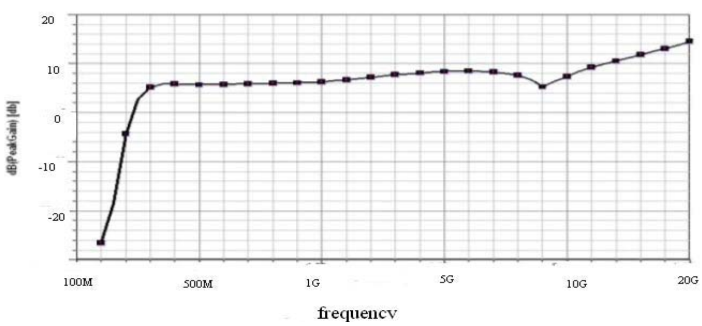

FIG 4; Frequency VS Gain (DB)

As it can be seen from Figure there are different ranges of frequencies in which the power is adequate for the harvester introduced in this paper. The main challenge in getting power from signals is their continuous frequency hopping. However, after studying these signals, it was found that the signals with frequencies within the 500 MHz to 1GHz range experienced less hopping as shown in FIG 5. Moreover, these signals carry more power

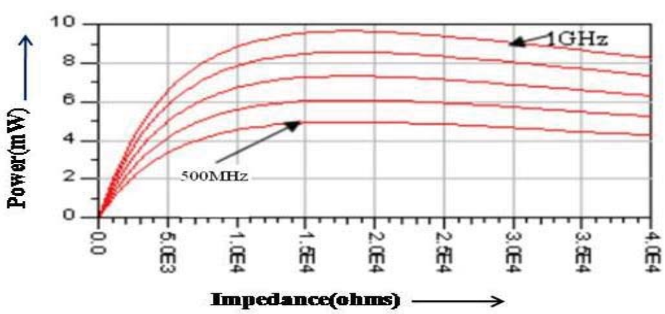

FIG 5; Load Vs Power

IV. CONCLUSION

In this paper, the combination of optical rectenna and super heterodyne concept is implemented to increase the efficiency of RF energy harvesting . Here the wide frequency spectrum utilized i.e; 10KHz to 22GHz for energy harvesting with the help of up and down frequency converter called heterodyne. Thus RF signal harvester for powering low consumption electrical devices was verified and simulated using MATLAB software.

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