Effect of Rectifier Stages and Load Resistance on RF Energy Harvester Circuit

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Abstract: **-Nowadaysbattery charging of smartphone and other low power devices has become a big problem. If user keeps on using data network or Wi-Fi that results to more drainage of battery. In this paper author proposed RF energy harvester network to reduce the drainage of battery. Variable input power and variable load resistance leads to the variation in the output voltage and efficiency of the circuit. It appears to be output has been achieved upto 1.8Volts and efficiency was achieved up to 70%.Matching network and rectifier stages also played a crucial role in the output voltage and efficiency of the circuit. Comparison of the same is also presented in this particular research paper.**

Keywords: Energy harvestor, matching network, RF to DCpower conversion.

1. INTRODUCTION

Today, human life is totally subject to advancement. Day by day new devices are being introduced in the market, along with that a problem is also taking a giant shape that is to keep those gadgets charged constantly. It looks easy when user do not frequently use those devices or keep them in the sleep mode, but when user keep on using them for some purpose battery start discharging. No one can tethered to the wall all the time to keep their phones or electronic devices fully charged. For that people choose other sources of charging like power bank or another spare battery for emergency. Due to which they need power to charge their devices. Especially mobile devices demand is continuously increasing and mobile charging has become a big issue in front of people.So energy harvesting technique is a big solution of this problem.

Energy storing can be done by three convenient methods, first by using sunlight, second by converting pressure into electrical signal and third and most reliable and efficient method is RF energy harvesting. RF signals are ambient resource and widely available 24X7.Harvester circuit include an antenna or RF signal receiver or transducer that convert the available RF energy into electrical signal. Then circuit has matching network which provide a lossless connection between transducer and rectifier. Rectifier network circuits have also a major role in energy harvesting. In which matching network circuits are used for matching the impedances of antenna with the impedance of rectifier. Matching is accomplished when maximum power is achieved and maximum power is achieved when proper matching is done between impedances of antenna and rectifier.

Some parameters have to be understood before making an RF energy rectifier circuit. They are,

(a) Distance between transmitter and receiver antenna.

(b) Different kind of antennas and its working frequency.

(c) Different kind of matching networks.

(d) How many number of multiplier stages can be used in rectifier circuit.

Working of RF energy harvester circuit can be analyzed by many ways, like output voltage and efficiency of RF to DC conversion. Basically surrounding environment and temperature conditions affect these factors and signal power of frequency band specially underlet this conditions. Its power changes with time, since clogs or eclipse due to high obstacles.Distance between transmitter and receiver is another parameter which highly affect the received power (Pr). Which can be represented by Friis transmission equation

$$P_r = \frac{[P_t G_t G_r]^2}{[4P_i R]^2}$$

Here P_r is for received power, P_t is for transmitted power, G_r is for receiver antenna gain, G_t is for transmitter antenna gain and R is for distance between receiver and transmitter. It can be easily understood by this equation that received power is inversely proportional to square of distance or remoteness amid receiver and transmitter.

Two strategies are utilized to get huge efficiency of adjustment. First one is to store the largest power by working in various band simultaneously and send it to the alternation circuit, second one is to compress the harmonics which is produced through diode.

Two domain can be used to store the RF power which are low region of power which is defined between 1uW and 1mW and high region of power which is defined 1mW to 100mW. But large sum of power is so hard to store at high region of power due to size complexity because when a single and large directive antenna is used. Need of increasing the number of antenna is required and when number of antenna increases to get this sum of power. The size and complexity of the circuit also increases. Since the RF power storing circuits are generally of low domain of power. So the storing circuit has to be made to available good performance in low domain of power.

Since huge amount of ambient RF energy isavailable, spread over several frequency bandsaccording to their application areas. Hence it ispossible to receive them in combined form andconverted into equivalent electrical energy byemploying appropriate circuit. The development on RF energy harvesting techniques provides reasonable solution of overcoming these problems. For charging of battery it is required that received RF signal is converted in to DC power through rectification. The procedure of correction of microwave signs to DC control has been proposed and inquired about on account of low power signal.

2. CIRCUIT DESIGN

In this paper creator proposed examination of three distinctive RF energy harvesting circuits. First circuit is having an antenna which is use to convert the received RF energy into electrical signal and following with the matching network which reduce the losses and provide a perfect matching environment for the antenna and the rectifier section. That rectifier has single stage voltage doubler and rectifies the received signal and provide a constant C output to the load circuit. Following is the first harvester circuit (Single Stage),

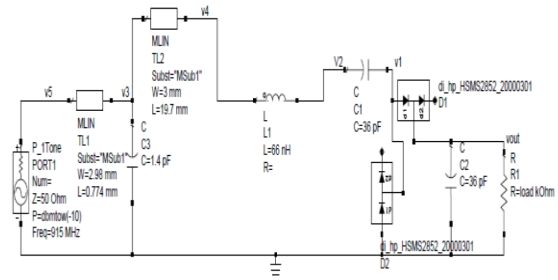

Fig.1: Single stage harvester circuit.

Another harvesting circuit comprises of 4 stages rectifier circuit that is the modified circuit of harvester presented in fig.1. that 4 stage harvester circuit is shown in figure below in fig.2,

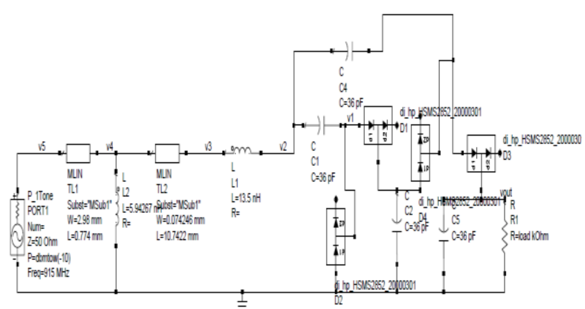

Fig.2: Four stage rectifier circuit.

Third and final circuit that was proposed by the author in this paper is 5 stage rectifier circuit, this circuit provide better efficiency and good output voltage as well.

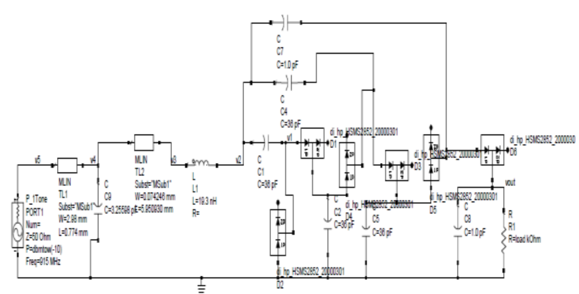

Fig.3: Five stage rectifier circuit.

The output DC voltage and conversion efficiency of RF energy harvester badly affected due to diode's nonlinear behavior and value of matching network's element. Hence efficient design of matching network is essential to get optimum performance. For L matching network consisting of series inductor and shunt capacitor, the element value may be determined by using design equations [1]:

$$B_L = \pm\sqrt{R_L(Z_o - R_L)} - X_L(1)$$

$$B_C = \pm\frac{\sqrt{(Z_o - R_L)/R_L}}{Z_o}(2)$$

For all these three different circuits presented above in fig.1,2 and 3, three different matching networks were designed and values of inductor and capacitor were calculated by above formulas.

3. RESULTS

Simulated results of the design in figure 1, 2 and 3 were analyzed and compared, the comparison graphs of all the three circuits are shown below. Efficiency of all the three harvesting circuits, and output voltage of all the three harvesting circuits were compared by varying the values of load resistance.

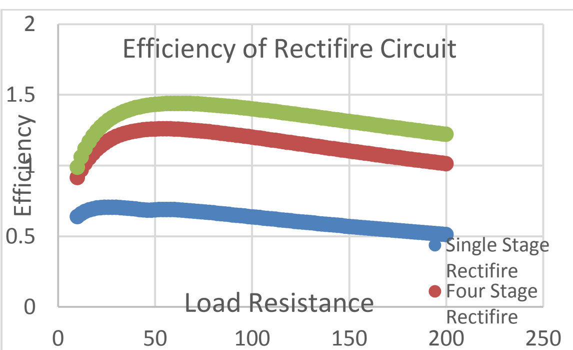

Fig.4: Efficiency of all the three circuits with variable load.

It has been found that by varying load at certaing value of load resistance efficiency of 70% has been achieved.

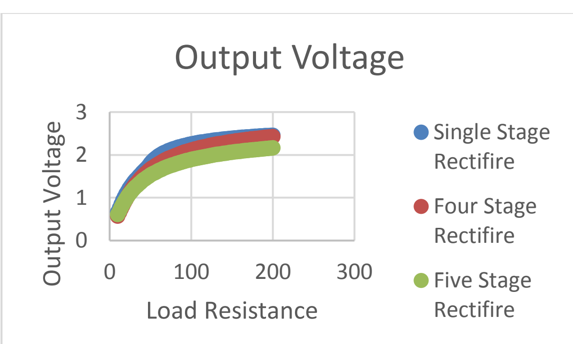

Fig.5: Output voltage of all the three circuits with variable load.

This comparative graph shown in above figure 5, represent the output voltage at a certain value has reached upto 2 volts. That is a significant achievement of having the efficiency above 70% and voltage arounf 2 Volts at the same value of load resistance.

4. CONCLUSION

In this paper the effect of matching networkelements on output voltage is presented as well as the effect of load resistance is also presented. It hasbeen observed that RF energy harvesting circuithigher efficiency and higher value of output voltage according to the stages of the rectifier. The significant improvement is shown by increasing the number of staged of the rectifier and with the variable load resistance. Variable input power can also be compared and results could be analyzed in further work.

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