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Modification using π Matching Network in Harvesting Circuit

Aparna Sikarwar
Research Scholar M. Tech.
ITM University
Gwalior (M.P.), [INDIA]
Email: apana199412sikarwar@gmail.com

Sumit Mohantey
Assistant Professor
Department of Electronics and Communication
ITM University
Gwalior (M.P.), [INDIA]
Email: sumitmohantey@itmuniversity.ac.in

Abstract*—In this paper an new and modified design is proposed to harvest available ambient source of RF energy. The impact of matching network has been studied and applied in this research to facilitate and improved the results of proposed designed circuit. Various matching network has been studied and pi matching network was selected in this design due to its significant result improvement factor. A continues effort results in an improvement output around 6volts. This voltage is sufficient to charge a battery of 50uAh capacity. In this research paper results of circuit with and without matching network were compared and presented.*

Keywords:— *Radio frequency energy harvesting, matching network, RF to DC power conversion.*

1. INTRODUCTION

Cellular phones has become a major need of this 21st century, it's hard to imagine a life without a smartphone in this digital world. And subsequently it's hard enough to get the phone battery charged all the time. Nobody wants to tether to wall all the time. There are many charging options are available in the market like power banks, separate battery backup plans but you need to charge those power banks too. Why don't we have a mobile which has a battery that last long for a week or a month without charging? It sounds impossible but it isn't, there are ambient resources of energy available in this atmosphere which can be used to charge our mobile phone or other low power devices. This energy can be energy radiated by sun or we can use our shoes as a charging source while walking using a transducer that can convert our pressure into an electrical energy which can be subsequently get amplified and fed to your mobile phone in your pocket. Or apart from these energy sources we can choose RF energy as our energy source to charge our mobile battery. The two main vibration based energy harvesting technologies are electromagnetic and piezoelectric. The electromagnetic harvester generates power from the motion of a coil due to host vibration in a magnetic field [5 -7].

Piezoelectric energy harvesters generate power from the strain in piezoelectric materials attached to the host, which vibrates in response to external excitations [8, 14, and 15]. Solar energy harvesting is the most attractive and suitable technology for wireless sensors [1] because of increased energy density and low cost of solar panels as compared to existing harvesting technologies such as vibration [2], wind [3] and thermal [4].

2. CIRCUIT DESIGN

The design of the energy conversion module in this article is based on a matching network circuit which can be able to output a DC voltage typically larger than a simple diode rectifier circuit. This module can function as an

AC to DC converter that not only rectifies the AC signal but also elevates the DC voltage level. The output voltage obtained from the energy conversion module can be used to energize the low power sensors in a sensor network. Basic block diagram of RF energy harvesting circuit is shown in figure 1. It contains.

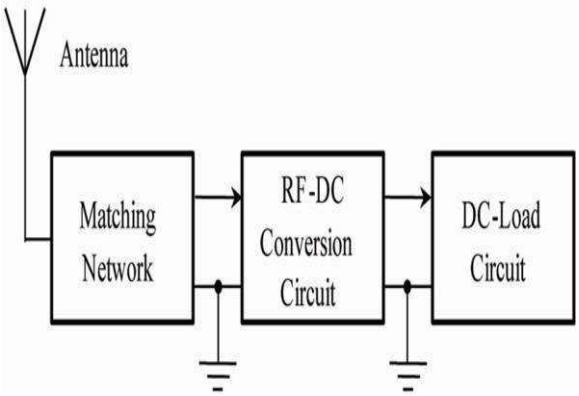

Figure 1: Proposed design structure presented in [2]

Ansoft Design software was used to design the proposed circuit, initially a harvesting circuit was designed without having a matching network, later on a π matching network was introduced in the circuit and afterwards results were compared. It has found after comparison that the matching network plays a important role in designing a harvesting circuit. ΠI matching network significantly increased the output voltage and maximized it to the desired level.

In following figure 2 the harvesting circuit without matching network is presented along with its simulation result in the subsequent figure.

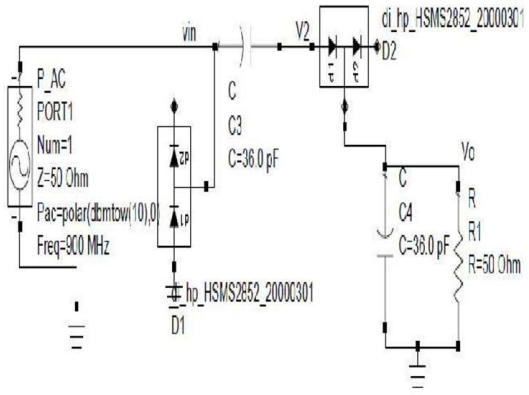

Figure 2: Designed circuit without matching network.

Figure 3: Simulated result in graphical form of circuit without matching network.

In following figure 4 the modified harvesting circuit having matching network is shown. This π matching network is introduced to enhance the output voltage of the harvesting circuit.

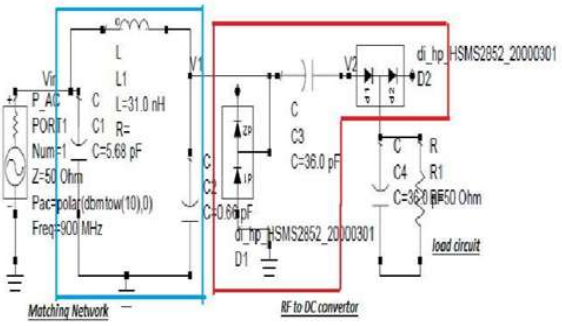

Figure 4: Designed circuit on ADS software with indicated parameters.

Following figures 5 & Table 1 having the simulated results of the proposed harvesting circuit implemented with matching network.

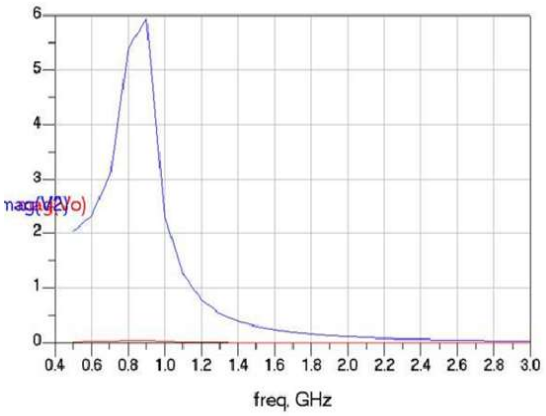

Figure 5: Simulated result in graphical form of circuit having MN which shows the maximum output of 5.9 Volts at the frequency of 900MHz.

Table 1: Simulated Result

Freq.	Mag(V2)
500.0 MHz	2.032
600.0 MHz	2.333
700.0 MHz	3.083
800.0 MHz	5.410
900.0 MHz	5.940
1.000 GHz	2.315
1.100 GHz	1.229
1.200 GHz	0.772
1.300 GHz	0.531
1.400 GHz	0.387
1.500 GHz	0.293
1.600 GHz	0.229
1.700 GHz	0.183
1.800 GHz	0.149
1.900 GHz	0.123
2.000 GHz	0.103
2.100 GHz	0.087
2.200 GHz	0.074
2.300 GHz	0.064

Table 1 shows the maximum output of 5.94 Volts at the frequency of 900MHz. After simulation of harvesting circuit without matching network, it has been found that the proposed circuit is not able to provide the desired output as it is only showing the voltage less than 0.5 Volts in the output. So to fulfill demand some amendment needs to be implemented. For such purpose a π matching network is introduced.

3. RESULTS

Simulated results of harvesting circuit with and without of the introduction of matching network is presented and analyzed. After comparison it has been found that there is a tremendous change in the results after incorporation matching network.

Results of harvesting circuit with and without matching network shown in figure 2 and 4 are presented in figure 3 & 5. Matching network provides maximum power transfer from receiving antenna to rectifier circuit so that conversion efficiency of the circuit may increase, because this circuit has to work with very low input RF power level.

4. CONCLUSION

In this paper the output voltage of a harvesting circuit has been improved up to 5.94 Volts, which is sufficient enough to charge a battery of 4.5 Volts. The comparison was done on both the circuits having MN or not and it has been observed that a MN plays an important role in designing a RF energy harvesting circuit. The output voltage was drastically changed by using a π matching network; it is far better option than having an L matching network.

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