Wireless battery charger using energy harvesting

Nesreen M. AL-Jezawi[1]

1 Jordan University of Science and Technology, Irbid, Jordan

** Corresponding author. Tel: 00962-786758253, E-mail:m_cresty@yahoo.com*

Abstract: As the world of development is going faster and faster by days, and the technology researchers think a lot of using wireless technologies in everything in life because of its benefits in everything.
The vision is to take advantage from these technologies and use it in designing one of the important and useful things, which is needed by all people daily.
The idea of thinking about designing a wireless charger will be so useful and gives device the ability to be more portable.
In this research, we design a wireless charger that convert the Radio waves at any frequency into a DC signal, and store it to be used by the battery of the device to recharge itself when it is needed, our design contains: rectifier, storage device, and control switch.
If any device has this wireless charger and it needs some power, then there is no need to use the wired charger to have the power, the wireless charger will supply its battery by taking the Radio waves and convert it to DC until the battery becomes full charging.
Because of our research, the design can be extended so that any device needs to be recharged can use the wireless charger to recharge itself like calculators, robots or any device.

Keywords: *Half Wave Rectifier, Low Power RF, LC Circuit.*

1.1. Introduction

With technology development in all world, this causes more use from electrical power so, we designed wireless charger to harvest Radio waves that it spreading in air.

Portable devices become more used these days, but while using them and switching them on all the time, this will cause the problem of having a power supply to charge them, which is sometimes not available as the person travels from a place to another and he cannot find the charger itself.

This causes a big problem of having the mobile switched on all the time, also using the wires is somehow not efficient as the wires may be affected by the natural factors like temperature.

To come up with a solution to these problems, it will be a good idea to think about taking advantages from the wireless technology and make a wireless charger to charge the mobiles for example anywhere, anytime and by anyone.

The idea behind that is to design a circuit, which takes radio wave by yagi antenna and converts it to DC format by our rectifier and store it in AAA battery to charge the mobile for example when it needs to be recharged.

1.2. Methodology

As said before, the main idea of the wireless charger designed is to charge the battery wirelessly from any source around, so in our design we assume there is an input source, which gives us AC power.

1.2.1. Related research work:

One of the researches done in such a topic was:

The idea behind this project is to capture the radio frequency sent by specific transmitter using energy harvesting circuit and store the energy in a stand then when mobile needs to be recharged, the user put it over the stand and it starts charging [1]

When comparing this design with the one we are trying to implement, we can find some differences listed below as e.g. Table 1:

Table 1: Comparisons between our project and this project.

Comparison	Wireless battery charging system using radio frequency energy harvesting,	Our Wireless Charger
charging way	The charger (the stand) needs a wired charger to work. I.e. If you go to any place, there is no power supply source, and the power of charger is low then you cannot recharge your phone by the stand.	The charger depends on places, which charger exists in it.
Usability	You need to check your phone always so you have to put it in the stand if it needs power.	You do not need to check your phone if it needs to be recharge or not because if your phone battery is low or, charger will recharge it by itself.
Design	What works wireless is the stand not the mobile.	The charging way: is by wires between your phone and the charger but the charger pick up the power wireless.

Other project, the idea behind this project is to design a transmitter and receiver and to send the microwaves using transmitted and received antennas.

It's somehow likes our design but the difference is the process of charging wirelessly happens between a specific and predestined transmitter and receiver while in our design the transmitter is any near voltage source [2] .and as comparison with our project, our wireless charger don't determine impedance for power transmitter .therefore, may be more losses in receive power .and as an overall design for it, we show as e.g. Fig. 1:

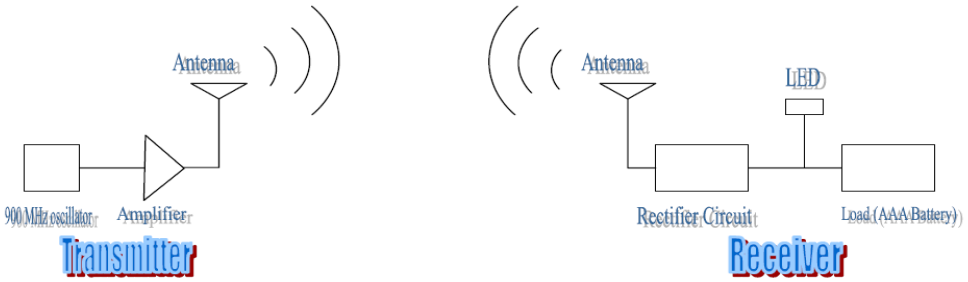

Fig. 1: transmitter and receiver in this project

1.2.2. Design:

We used LC Circuit like an antenna …as the sensor senses any power source around, the antenna starts taking Radio waves from the air.

After getting the RF power by the antenna, it is used as an input to a converter circuit; these circuits, which convert AC power to DC power, then save it in battery, and next step used two tri-state buffers to charge control, each 5s we put enable is '1' the device takes power that stored in wireless charger, finally we put enable is '0' until 1s to recharge the capacitor and so on, as Fig. 2.

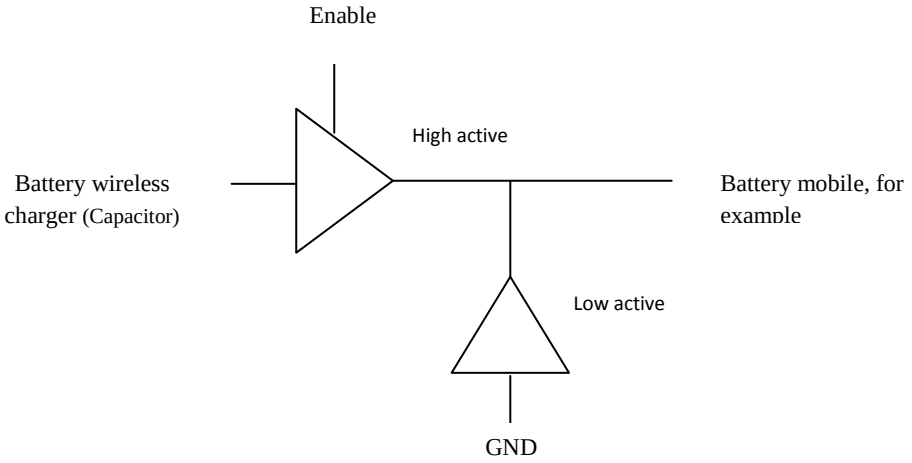

Fig. 2: diagram for control switch.

The circuit consists of clamper and half wave rectifier with the germanium diodes and capacitor to make nearly DC signal and to less losses input harvest power as Fig. 3 that it show the diagram for all project. In design you can use many stages to get suitable power value.

Therefore, in our design we use one of the simulation tools to test our circuit, we used a 'circuit maker tool' to draw the circuit and test it.

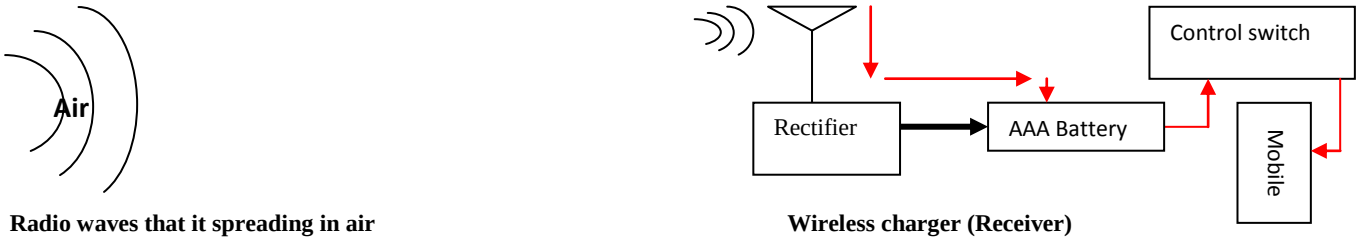

Fig. 3: diagram for wireless charger project.

1.2.3. Simulation Requirements:

1. LC circuit (as antenna in real practice) as Fig. 4.
2. Diodes (Gi- threshold for it (0.2-0.3) V).
3. Capacitors.
4. Battery.
5. Resistance.
6. Voltage source (1V, 910MHz).
7. Control Switch.

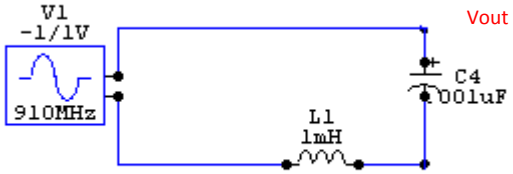

Fig. 4: LC Circuit.

We assume LC circuit instead antenna in simulator "Circuit Maker Tool", on assumption, because it nearly the same work.

We used voltage doublers as rectifier to convert AC-DC, finally connect it with AAA battery to store the power.

1.2.4. Statistical or mathematical methods:

P (Avg) =I (Avg) .V (Avg) …Eq. (1).

Where I (Avg) is average current, and V (Avg) is average voltage.

Energy=.5*C*V …Eq. (2).

Where C is capacitor value and V is capacitor voltage.

T=I*Q …Eq. (3).

Where T is capacitor time to full charging, and Q is charge (Q=C*V).

1.3. Results

New technologies discovered must be tested and simulated so we can be sure if it really works as expected and if it serves its purpose or not.

Because of thinking about making and designing a wireless charger, it is necessary to be tested to know if we can really take the power from any device around or not.

Here is a figure that displays the practical design for the circuit as Fig. 5:

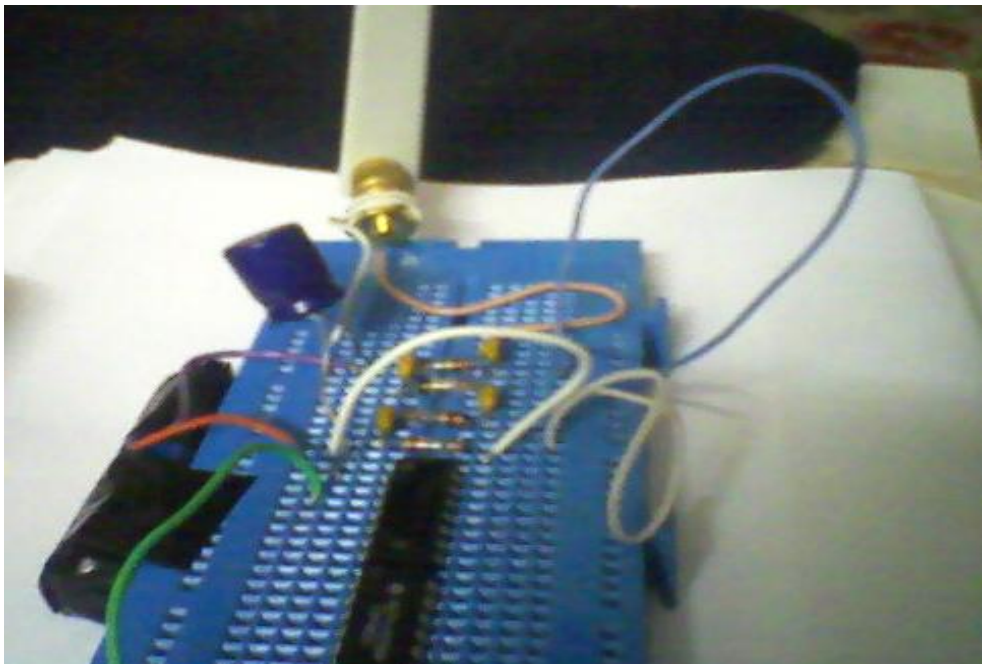

Fig. 5: picture for real design.

Now we will display our design for wireless charger using Circuit maker tool as Fig. 6:

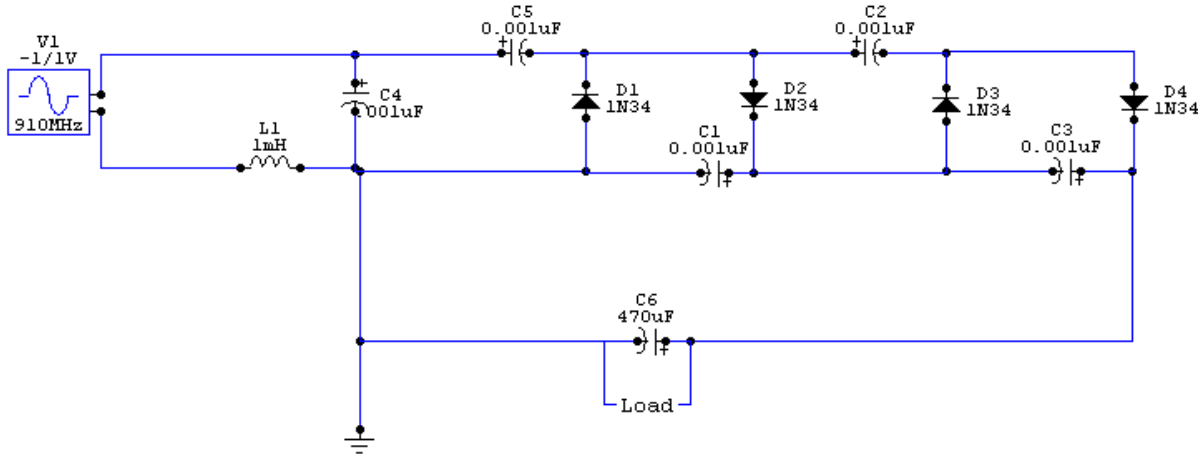

Fig. 6: Wireless Charger Circuit.

Our wireless charger circuit can receive any frequency .So, to determine the suitable frequency to get suitable output power depend on Eq. (1) we test it as Table 2:

*Table 2: Output table *.*

Input Parameters				Output Parameters	
L1	C4	F	V1	V (DC-AVG)	Power (AVG)
1mH	0.001µF	60H	-1/1V	6.151µV	$3.78*10^{-9}$ W
1mH	0.001µF	910MH	-1/1V	19.98mV	$3.99*10^{-8}$ W
1mH	0.001µF	2.41GH	-1/1V	20.26mV	$4.1*10^{-8}$ W

* C1, C5, C2, C3=0.001µf, R1=10KΩ , C6= 470µF.

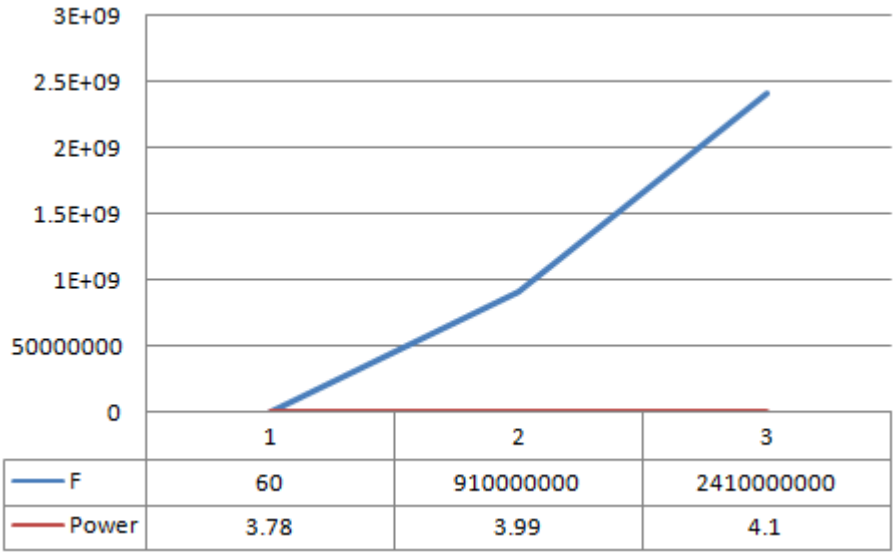

Fig. 7: relation output power with frequency

We will calculate capacitor energy depend on Eq. (2) when becomes capacitor full charge to expect heat on it:

60H ------ Energy= $1.445*10^{-9}$ J

910MH ------ Energy= $4.695*10^{-6}$ J

2.41GH ------ Energy= $4.761*10^{-6}$ J

As we know, increase frequency gets more power and energy, but it cause negative effect on human.

We calculate capacitor time to full charging depend on Eq. (3) as Fig 8:

Table 3: Relation between input frequency and charge with time.

Input Parameters	Output Parameters	
Frequency	Charge (Q)	Time (T)
60Hz	$2.89*10^{-9}$ C	$1.77*10^{-12}$ s
910MHz	$9.39*10^{-6}$ C	$1.875*10^{-11}$ s
2.41GHz	$9.52*10^{-6}$ C	$1.923*10^{-11}$ s

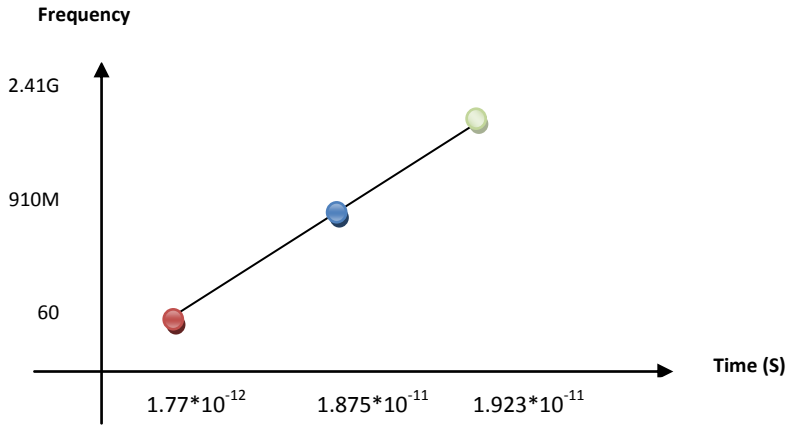

Fig. 8: relation between frequency and time.

As practical test the circuit working with different frequency but the best result when frequency between 2.4- 4.835 GHz as Fig. 6, this compatible with if we work with high frequency, we will get more power.

The average power value of the output after loses by using simulation test was $4.1*10^{-8}$ W, which is enough to recharge the battery, but your mobile for example need more time to recharge it.

1.4. Conclusions

The use of technologies has increased lately, and the uses are searching for everything can make their lives as easy as possible, so to implement such an idea will be useful and serve many people who really need their mobiles to be charged in some critical situations and far places where wired electricity is not available.

Therefore, by this design, we try to minimize the problems, which may be appeared when using such a wireless charger.

This is done by choosing a standalone receiver without thinking of how the transmitter shall be, and by choosing the best AC to DC converter so that the power will not be lost through the charger itself.

In our project Idea we focused on wireless charger circuit do not need any power to charger itself.

References

[1] "*Wireless battery charging system using radio frequency energy harvesting*", university of Pittsburgh, 2004.

[2] Eric Lo, Hau Truong, "*WIRELESS BATTERY CHARGER*"by (RF/ Microwave to DC Conversion), Dec 02, 2005, Louis Elnatan, Alvin Mar and Ha Nguyen.

[3] "*An Integration Scheme for RF Power Harvesting*", H.Yan, Student Member IEEE, J. G. Macias Montero, A. Akhnoukh, L. C. N. de Vreede, Senior Member ,IEEE, and J. N. Burghartz, Fellow, IEEE.