Wireless Energy Harvesting to Charge Cell phone Batteries

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Abstract- **The research deals with the charging of cellphones wirelessly using various techniques. A voltage doubler circuit assembled with a "more" efficient circuit definitely makes this project a brighter innovation.**

Index Terms– **Wireless ,Energy, harvesting, charge, cellphone, batteries.**

I.INTRODUCTION

Cellular telephone technology became commercially available in the 1980's. Since then, it has been like a snowball rolling downhill, ever increasing in the number of users and the speed at which the technology advances. When the cellular phone was first implemented, it was enormous in size by today's standards. This reason is two-fold; the battery had to be large, and the circuits themselves were large. The circuits of that time used in electronic devices were made from off the shelf integrated circuits (IC), meaning that usually every part of the circuit had its own package. These packages were also very large. These large circuit boards required large amounts of power, which meant bigger batteries. This reliance on power was a major contributor to the reason these phones were so big.

Through the years, technology has evolved itself in such a manner so as to reduce the size of the battery by using various more efficient components. But still the main problem that persists is : Charging your cell phone, by connecting it to a plugged in charger. So being a student and facing a problem of lack of resources, it gave me an impulse to take a step, and work on the same and find a decent alternative to charge our cell phones, without plugging them on the wall.

There has been research done in the area of shrinking the charger in order to make it easier to carry with the phone. One study in particular went on to find the lower limit of charger size. But as small as the charger becomes, it still needs to be plugged in to a wall outlet. How can something be called "wireless" when the object in question is required to be plugged in, even though periodically?

Most of us do not realize the presence of large amounts of energy around us. Radio and television towers, satellites orbiting earth, and even the cellular phone antennas are constantly transmitting energy. What if there was a way so as to capture this energy, and store it so as to power some device in times of need.

This sounds vague, and hypothetical but this can be achieved by using a concept called- "Energy Harvesting". Energy Harvesting is the idea of gathering transmitted energy and either using it to power a circuit or store it for later use.

So the most important concern in this process is the antenna to be used and the circuitry to be designed.
As stated in earlier research, experiments have been conducted by using single pole and dipole antennas. But proper study and research has shown that the efficiency can be improved by using a Quarter Wave Chip Antenna.
As already discussed , Section I deals with the introduction , Section II with the components of the project , Section III with the Result Analysis , Section IV is the Conclusion followed by Acknowledgement and References.

II.COMPONENTS

A. *The Transmitter*

The most basic transmitter setup includes a piece of circuit that generates a piece of signal which is then fed into an amplifier ,that is finally output through a radiating antenna- the air interface. In the present case we connect the RF source to an amplifier followed by an antenna. But the RF Source generates only in the range of 3 MHz-3Ghz,and hence the need of amplifier arises. The project involves a RF of 915 MHz as its easily implementable and does not interfere with any other frequencies.

B. The Phone

The most crucial part and the area of research in this project, is the receiving side. Hence considering the idea of Wireless Energy Harvesting to be feasible , we figure out that the energy harvesting circuitry and also the antenna can be incorporated within the cell phone but by compromising on the size of the cell phone.

C. The Background

The general idea of this project is to capture the wireless energy available all around us using an antenna and then transmit it to the energy harvesting circuitry then followed by the output device. Earlier Research projects have been carried out on Energy Harvesting circuitries which stored the energy captured and were used to light and LED. This happened when the capacitor connected , was totally charged which then gave off its charge to the LED
(It is known as Charge and Fire System).

As the size of the battery has to be maintained small, RFID systems (the older ones) cannot be used. But, with a good antenna, a charge pump should be able to handle the powering of these circuits and never will need to be serviced. Because the circuits are small, the power required is minimal.

D. The Charge Pump

It is initially most important to explain what a charge pump actually means. It is basically a circuitry that converts an AC signal to a DC signal and also raises the amplitude of the same signal.
So it is similar to the power converter circuits used these days in modern equipments. But those circuitries are larger in size, as they also contain a protection and noise reduction circuitry which thereby increases the size.

The simplest design that can be used is a peak detector or half wave peak rectifier. This
circuit requires only a capacitor and a diode to function. The schematic shown displays that during the positive half cycle of the signal the the diode is in the ON state and hence the capacitor gets fully charged, and hence it remains at that level if no load is connected (or else the voltage drops by a certain value).So the capacitor now has a voltage built up, which is equal to the peak value of the AC current and hence it is also called as peak detector.

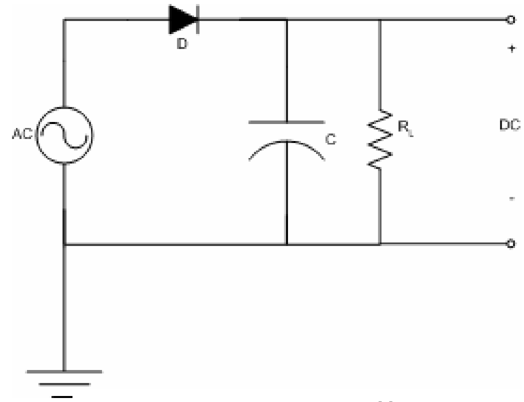

Figure1. Half wave peak rectifier[1]

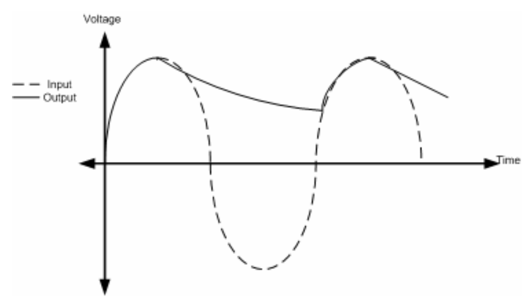

Figure2.Voltage-Time Curve for Half wave rectifier. [1]

The nature of the output waveform is such because of the RC time constant. The voltage decreases inverse to the resistance(R) of the load multiplied by the capacitance(C).

The next technique that can be used is using a full wave rectifier. Whereas the earlier circuit only captures, the positive half of the signal, this rectifier also captures the negative half.
During the positive half cycle the D1 diode is on and hence ,the capacitor is charged. During the negative half-cycle D2 is ON and hence the capacitor is charged. Though there is some drop in the voltage, it is very less also the noise is reduced as compared to the earlier case.

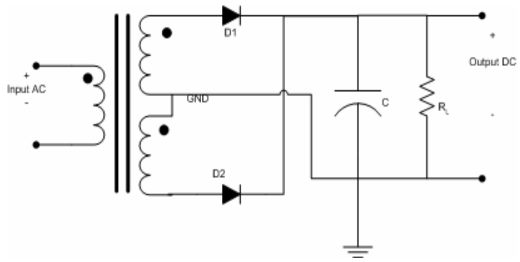

Figure3.Full wave peak rectifier[1]

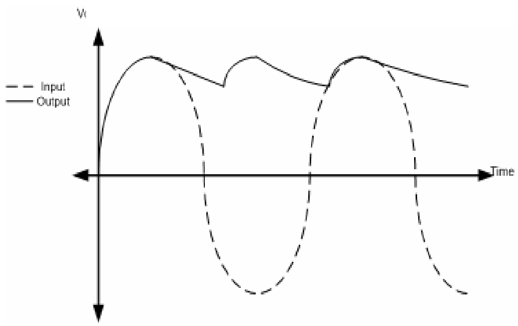

Figure4.Voltage-Time Curve for Full wave rectifier[1]

Though this circuitry is quite efficient it is not used as it is a huge circuit and requires a lot of space which is against the need of the situation.

Instead what we use is a voltage doublers which is a series of elements which helps to multiply the input voltage at each stage.

In earlier research projects conducted, the charge pump used had a series of diodes and capacitors which doubled the input voltage. Similarly, we can also use a voltage quadruple circuit that will give output voltage=4*(input voltage). A "Voltage Quadruple Circuit" can be constructed by cascading together two full voltage doublers circuits as shown. The first stage doubles the peak input voltage and the second stage doubles it again, giving a DC output equal to four times the peak voltage value (4Vp) of the sinusoidal input signal. Also, use large value capacitors to reduce the ripple voltage. By cascading together individual half and full multiplier stages in series, any desired amount of voltage multiplication can be obtained and a cascade of "N" doublers, would produce an output voltage of 2N.Vp volts .

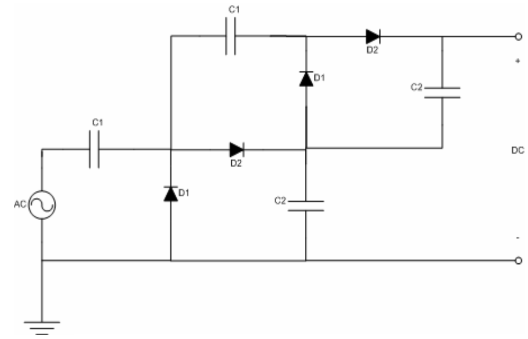

Figure5.Voltage Doublers Circuit[2]

E. Antenna

The second most significant part of any charging system is also the antenna being selected. Earlier the antenna used to capture the radio frequencies were the single pole, dipole and monopole antennas.

The monopole antenna is not preferred because of the directional nature of it and hence though it has an advantage of shorter length as compared to the conventional dipole antennas used, it has a very strong directional nature and hence it cannot capture the frequencies, below the ground plane .

The visible efficient manner, though theoretically proved to overcome the above problems is using a Printed Circuit Whip or "Stub".

The best part of Stub is that, it can be traced/printed on the surface of the printed circuit board(PCB).And this is very practical at frequencies above 800 MHz(The case in our project),because at lower frequencies the whip may be too long, even if its wrapped around the corners.

Discussing in detail about this enhanced feature, is that the whip can be traced on the surface of the PCB ,with a chip inductor to tune out the capacitive reactance of the antenna. Earlier experimental approaches show that if the trace runs parallel to ground, the real part of the antenna impedance will be

approximately 10 ohms. In a hand-held unit, the impedance will be raised substantially through hand effects. For a tenth wavelength strip on a board with hand effects included, the antenna has a capacitive reactance of about 150 ohms.

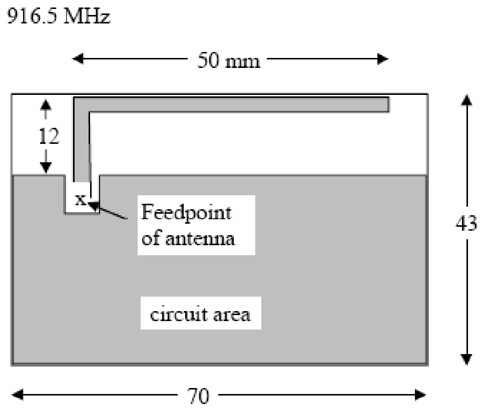

Figure6.Printed Circuit Whip or “Stub”[4]

Tuning is not extremely critical, small variations in inductor value or antenna length will not have a great effect on performance. Our sample designs, at 915 MHz, resulted in maximum gains of between -12.5 to -14 dBd off the side of the board. The null dipped down to about -26 dBd. This is more unidirectional than some other designs, and hand effects will help to reduce the null depth.

The key to this design is to keep resistive losses low, use wide traces (if a PCB trace), and good quality inductors. Adjust the inductor value for maximum output in the environment that it will be used. Gain can be improved by making the whip longer and thus reducing inductance. But, in some cases, it may be better to shorten the trace and add inductance rather than to run the antenna close to other circuit board traces.

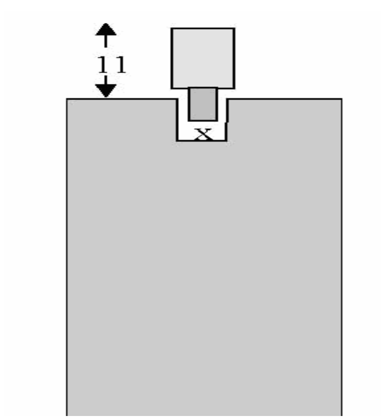

Figure7.“Chip” Antenna[4]

The above mentioned Stub can also be replaced by the latest in market “Chip” Antennas. These antennas are similar to whips in behavior, only much smaller. If an antenna can be reduced in size, while maintaining efficiency, bandwidth will be reduced. So these devices have a very narrow bandwidth and must be made to the exact frequency. So further research can be performed on the same and hence the efficiency and compactness of our system can be enhanced.

F. Voltage Stage Doubler

Previous research shows have been conducted on 7 and 8 stage voltage doublers circuits and also on the 5 stage voltage doublers circuits.

The research and simulations shows that the process of having the value of the capacitance at each stage halved does not make a major difference and hence it is considered that the task of getting the exact logic of using the capacitors is complete .

III.RESULT ANALYSIS

A. Phone Testing

Previous work on the project of charging a cell phone battery showed that the two end terminals did not provide enough charge and hence it could not prove itself to be a more efficient way to charge the battery.

So recent research by me show that the efficiency tends to decrease when the harvesting circuit terminals are connected decreased because the voltage generated gets wasted when connected to the THERMISTOR/cell balancing terminals(in case of 4 pins, or even for 3 pins).

As with 3 pins on the cell phone battery, the third terminal is connected to the internal thermistor which helps to protect the battery from getting over heated.

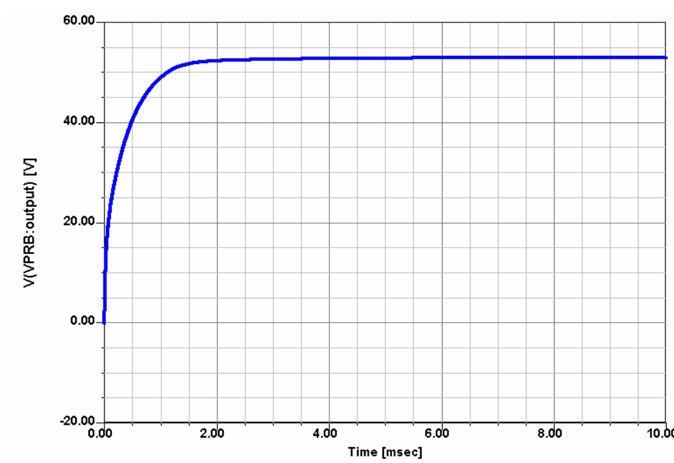

Figure8.Voltage Stage Doublers with Equal Capacitance[2]

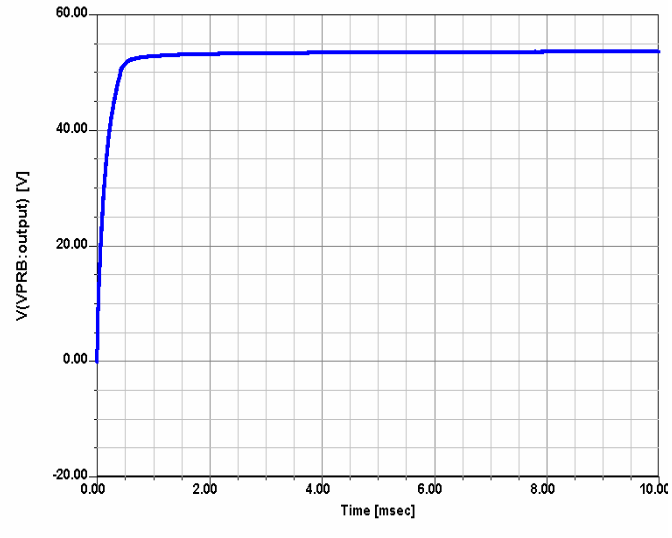

Figure9.Voltage Stage Doublers with Varied Capacitance[2]

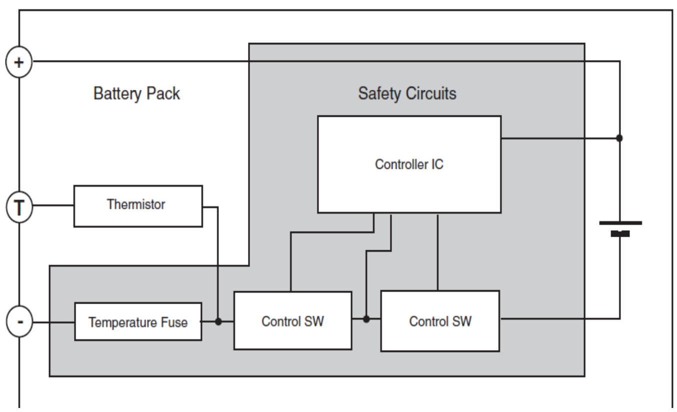

Figure10.Phone Testing Circuit

IV.Conclusions

I have been working on this topic and concept since a long time now , and hence the passion to contribute to the science is great and I would also like to work on the same area of research further . The advancement in the research will be by making this circuit design as compact as possible so that it can be practically implemented for users as soon as possible.

Acknowledgement

I would like to thank my family who have always supported me in my work, and friends and professors at my university who have guided me on technical aspects and made this work possible.

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