Proceedings of 2015 3rd International Conference on Advances in Electrical Engineering
17-19 December, 2015, Dhaka, Bangladesh

Mobile Phone to Mobile Phone Wireless Power Transfer

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***Abstract*— Wireless power transfer (WPT) or wireless energy transmission is the transmission of electrical power from a power source to a consuming device without using solid wires or conductors. In this paper we describe the implementation of the concept of wireless power transfer to transmit power from mobile phones to mobile phones. In our design we use simple inductive coupling and basic electrical circuits to implement this technology.**

Keywords—wireless power transfer; OTG; resonance; inductive coupling; Colpitts oscillator; voltage regulator

I. INTRODUCTION

In recent times, Wireless Power Transfer technology has opened a window towards a new revolution. It changed the general perception of transferring power. Commonly known as WPT, this technology can ease the way of energy transmission widely. Back in 2006, a group of MIT students came up with this innovative way to light a 60W bulb over two meter distance wirelessly. This amazed the concerning people with a hope to use the old theories in a new way. This noble concept was far foreseen by the “Father of Wireless” Nicola Tesla based Tesla theory, which would transmit the electrical energy across a large distance and receive it at the destination with negligible losses. We used this concept to make an efficient power transfer system to transmit a low voltage power over a short distance. We aim to charge a phone with 5V energy transferred through resonating coils from an On-The-Go (OTG) supported phone. An OTG supported phone can deliver 5V DC output which we intend to use to charge another phone [7].

II. RELATED WORK

Engineers have been striving to find better ways to recharge mobile phones. With the development of modern technologies, they were able to invent a new wireless charging technique. It includes a wireless charging pad which will recharge a device when kept over it. Besides recharging mobile phones engineers have used this device to wirelessly operate lights, laser etc. A group of researchers from, School of Electrical System Engineering, University Malaysia Perlis has published a study similar to our solution [3]. Although, the researchers tried to transfer the required voltage through coupling coils instead of implementing any more circuit on the receiver except rectifier. The study did not include the physical implementation of the idea to charge phones, rather it concentrated in wireless power transfer.

III. WIRELESS MOBILE CHARGING FRAMEWORK

We receive a 5V DC power from an OTG supported phone. This DC power is converted into a high frequency AC signal with the help of a Colpitts Oscillator. The high frequency AC signal is transmitted through a magnetic coil at the receiver end. The high frequency AC input form the coil is passed through a full-bridge rectifier circuit. This converts the AC signal into DC power which is then boosted to 5V using a step-up Voltage Regulator.

IV. THEORY

The basic idea of the system is to take the power from a charged phone and deliver it to another one wirelessly. The wireless power transfer of the system is based on inductive coupling between transmitting and receive coil. The transmitting phone needs to support USB OTG (On-The-Go) to draw the power into the system. USB OTG is a specification first used in late 2001 that allows USB devices such as mobile phones to act as a host, allowing other USB devices such as USB flash drives, digital cameras, mice or keyboards to be attached to them. This allows it to dissipate constant +5V voltage and up to 1.5mA current (depending on USB version and protocols) [6]. We can use this power to serve our purpose.

Fig. 1 shows the basic block diagram where the oscillator generates an AC power and transfers it wirelessly through coupling coils. The AC power is then rectified to DC with a simple full bridge rectifier. The DC power is then converted to 5V DC with a voltage regulator working as boost converter.

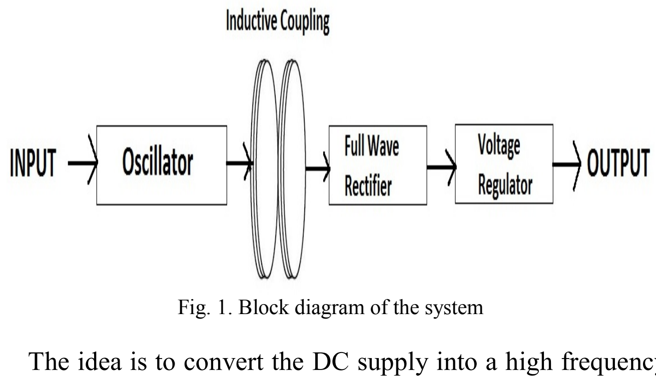


Fig. 1. Block diagram of the system

The idea is to convert the DC supply into a high frequency AC supply with the help of an oscillator, which we need in order to transfer wirelessly [7]. For the oscillator we used a simple Colpitts oscillator. The oscillator is a simple one to implement and being a current oscillator it is helpful for the system [1]. The AC power is then transferred wirelessly through inductive coupling. In inductive coupling power is transferred between coils of wire by a magnetic field. Fig. 2 shows the block diagram for the wireless power transfer through inductive coupling. The transmitter and receiver coils together form a transformer. An alternating current (AC) through the transmitter coil (L1) creates an oscillating magnetic field (B) by Ampere's law. The transmitting coil (L1) is coupled with the receiving coil (L2) at the same frequency. This allows the magnetic field (B) to pass through the receiving coil (L2). The system induces an alternating EMF following Faraday's law of induction, while creating an AC current in the receiver. One important parameter for coupling is frequency, as the efficiency shows a proportional relationship with frequency for such systems [9].

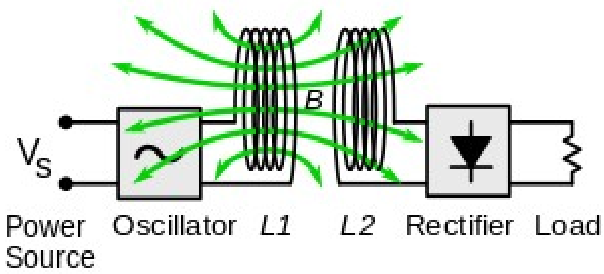


Fig. 2. Block diagram of WPT (Collected from [9])

Both of the coils act like a transformer, using which the power is transferred. The transferred power depends on the coupling frequency and mutual inductance (M) between the coils. As a matter of fact the output power increases with both the parameters, which can be manipulated since M depends on the geometry and the distance D_{range} between the coils. Another important parameter is the coupling coefficient

$$k = \frac{M}{\sqrt{L_1 L_2}} \tag{1}$$

When, the distance between the coils is zero, the parameter k=1, which is the maximum possible value for k. It theoretically means the link efficiency is 100%. The lower the value the less efficient our link becomes [9].

In the receiving side, the output of receiver coil is passed through a full bridge rectifier and converted to DC. The Dc power is than passed through a voltage regulator to boost the expected low voltage into 5V DC power which is required for the load of the system.

V. SYSTEM SETUP

The setup of the system has been discussed below.

A. Transmitting End

The system will get a 5V DC input from a mobile phone. This power will consequently reach the receiving phone and recharge the phone. So, the DC voltage is passed through a Colpitts oscillator so that it is transformed into an AC signal. High frequency AC frequency is required to transmit the power wirelessly through magnetic wires. The higher the frequency gets, the better the coupling occur. For the oscillator, NPN transistor is chosen. The resistances and capacitors are connected to a BC-548 (NPN) transistor in the design of the Colpitts oscillator. Multiple transistors were connected in parallel to improve the supply current.

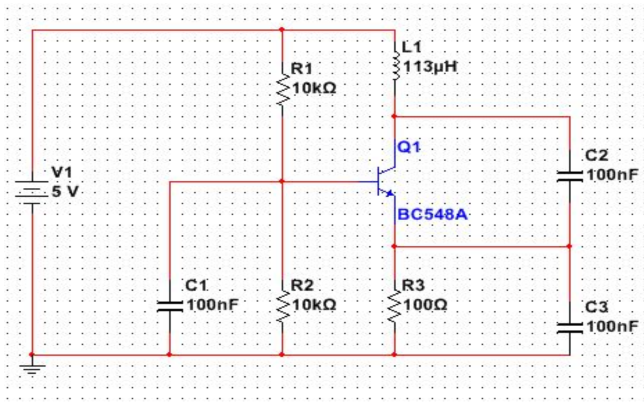


Fig. 3. Transmitting end

B. Coupled Coils

The transformed AC voltage is passed through a magnetic coil. For this system, a 24AWG Magnetic Enameled Wire have been used. The diameters and number of turns of both the transmitting coil and receiving coil are chosen in such a way that they both resonate at the same frequency. The diameter and number of turns were arbitrarily chosen to be 15cm and 20 turns respectively. The coils were then separately connected to the transmitting end or Colpitts oscillator. The number of turns of both the coils were varied to get the expected outcome. When both the coils resonated at the same frequency, then the receiving part was accordingly. The chosen frequency was 66 KHz approximately. To find the inductance of the coils, the following formula were used:

$$freq = \frac{1}{2\pi\sqrt{ind \times \frac{cap}{2}}} \tag{2}$$

$$ind = \frac{\left(\frac{1}{freq \times 2\pi}\right)^2}{\frac{cap}{2}} \tag{3}$$

Thus the inductance was found to be 113 µh.

C. Receiving End

The receiving coil was connected in parallel to the coupling capacitors of 100nF. These capacitors helps the coils to improve coupling co-efficient.

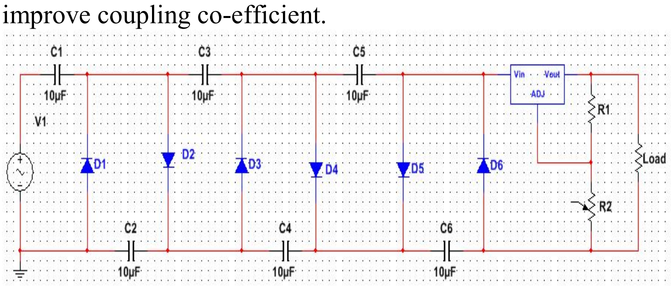


Fig. 4. The receiving end

In fig. 4, the AC signal from the coil is passed through a Cockroft Walton (CW) voltage multiplier. A CW multiplier generates a high DC voltage from a low voltage AC. Hence, it can rectify the received AC voltage, as well as, step up the relatively low voltage. This is a classic multistage diode/capacitor voltage multiplier, which is economically efficient at the same time. The stages can be increased or decreased with ease to get desired output. The final voltage output of the stages is given by (4).

$$V_o = 2NV_p = NV_{pp} \tag{4}$$

where N is the number of stages.

This DC voltage is then regulated with a Voltage Regulator circuit. The idea of this regulator is to control the output voltage while changing the value of R1 and R2 from fig 4. The voltage can be controlled by using (5).

$$V_{out} = V_{ref} * \left(1 + \frac{R_2}{R_1}\right) + (I_{adj} * R2) \tag{5}$$

where Vref is the voltage between Vout and adjustment pin and Iadj is the current through adjustment pin.

The voltage regulator has been chosen to keep the system simple and upon simulation results. Depending on the practical scenario which might vary, as there are lots of boost converter mechanisms to boost and control the DC power.

VI. RESULTS AND DISCUSSION

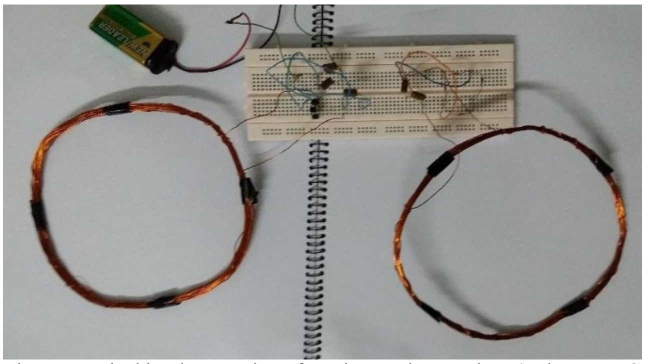
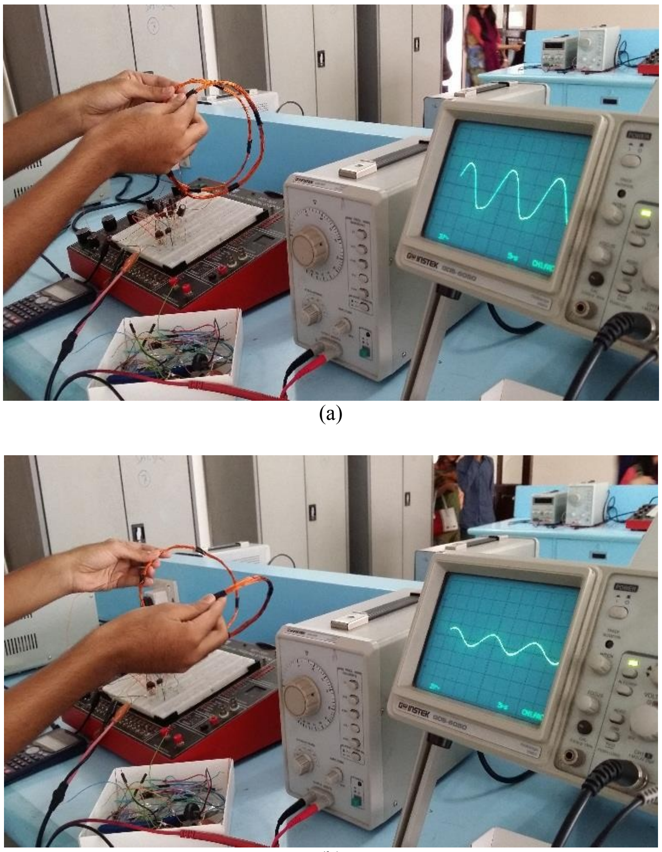


Fig. 5. Practical implementation of receiver and transmitter (Using 5V DC battery)

Fig. 5 shows the practical circuit design. The left portion of the design is the transmitting end and the right portion is the receiving end. Here, the voltage regulator circuit is not implemented.

The output of the receiving coil was measured in the lab in various circumstances. We took 5V DC from the power supply as our input power of the transmitting end.



(a)

(b)

Fig. 6. AC output across receiver (a) coils are near each other (b) Coils are taken further away

Fig. 6 shows how the change in distance between the coils changes the output AC. As we can see when the coils are closer the amplitude is better. The closer the coils, the better the efficiency. At approximately, 2 cm distance we got 3.4V AC output from the oscilloscope reading. Whereas, the RMS value measured was 3.26V.

This paper has been done as the project is ongoing and thus the results are only from the parts and experiments we have conducted so far. The voltage regulator has not been implemented here but we expect to have our desired output as it was simulated successfully.

VII. FUTURE WORK

There is a possibility that the Voltage Regulator used, might not meet the requirements of the system. Very high resistance value is required to attain the 5V DC output using this regulator. Although, similar topologies using MAX756 or MAX757 IC might be an optimum solution to this problem. It steps up voltage within 0.7V – 5.5V to 2.7V – 5.5V [11]. MAX757 can be adjustment according to the requirement, whereas MAX756 gives fixed 5V DC output.

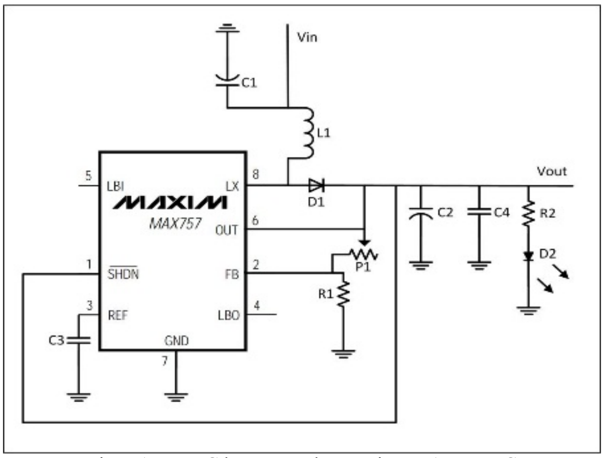


Fig 7 A 5V DC boost regulator using MAX757 IC

In future, this system can be built within the phones and thus no external device will be required to enjoy its service. The coil can be built using PCB boards which can be installed within the mobile phones. Two such phones will then be able to share the power within them using this technology.

VIII. CONCLUSION

In this paper, we have described a mechanism to transfer a low power DC voltage from one mobile to another for the purpose of charging the phone. We have dealt with coupling coils and their resonance. Colpitts Oscillator, Full-Bridge Rectifier and Voltage Regulator circuits have been implemented. This project gives us a new and convenient option of recharging our phones at times when charging from a phone remains the only option because of the lack of having proper charging outlets. This simple idea is a feasible and inexpensive one for mobile charging.

ACKNOWLEDGEMENT

This work is done as part of an undergraduate Capstone Design course in the Department of Electrical and Computer Engineering of North South University, Dhaka, Bangladesh. We cordially thank and gratefully acknowledge our supervisor Dr. Hasan Uz Zaman for his helpful suggestions and directions, which have improved the work. We also thank the Department of Electrical and Computer Engineering of North South University for giving us the opportunity to work on this project.

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