International Journal of Advances in Applied Sciences (IJAAS)
Vol. 7, No. 2, June 2018, pp. 191~198
ISSN: 2252-8814, DOI: 10.11591/ijaas.v7.i1.pp191-198

Super Capacitor Electronic Circuit Design for Wireless Charging

A. Hameed[1], Lway Faisal Abdulrazak[2], Zaid A. Aljawary[3]
[1]Assistent Professor, Department of Mechatronics, Universiti Malaysia Pahang, Malaysia
[2]Lecturer, Department of Computer Science, Cihan University-Sulaimanyia campus, Iraq
[3]Assistent Lecturer, Department of Information Technology, University of Human Development, Sulaimanyia, Iraq

Article Info

Article history:

Received Nov 9, 2017
Revised Feb 20, 2018
Accepted May 11, 2018

Keywords:

Fast-charging
Ultra capacitor
Wireless charging

ABSTRACT

Keeping time as base, a gadget has been proposed, where electrical accessories like Mobiles are charged within a fraction of minutes which is highly efficient and time saver as compared to the present time chargers which take nearly two hours to get fully charged. Objective of this project is to create a circuit which will be charged quickly and wireless. Wireless charging circuit works on the principle of inductive coupling. AC energy has been converted to DC energy through diode rectifier. Oscillator circuit produces high frequency passed by transmitter circuit to transmit magnetic field which is received by receiver circuit. A wireless charging concept with super capacitor will lead to faster charging and long operative life. Here super capacitor is used as a storage device. A Super capacitor has magnificent property, it can charge as well as discharge very quickly and linearly alike battery. The main difference between battery and super capacitor is specific energy, Super capacitor have 10-50 time less than battery.

Copyright © 2018 Institute of Advanced Engineering and Science.
All rights reserved.

Corresponding Author:

Lway Faisal Abdulrazak,
Departement of Computer Science,
Cihan University–Sulaimanyia Campus,
Sulaimanyia, IRAQ.
Email: lwayfaisal_abdulrazak@yahoo.com

1. INTRODUCTION

In day to day life electronic gadgets are used very frequently; the main function of these gadgets is to make living comfortable. These gadgets are used in various applications and fulfill our desires. Charging of Gadgets like Mobile, it takes 1-2 hours in a day to run it for whole day, makes one of the big issue for efficient and continuous work. A small step towards fast charging has been proposed in this paper where we are concerned about the charging of electronic devices like Smart phones [1]. Smart phone are quiet Popular nowadays. Our project is related to charge mobile phone without any USB and it will charge the mobile in very less time. Our work is focused on wireless power transfer (WPT) as well as on the reduction in charging time. Imagine, if there is no socket available near the user to put the phone on charge and user is busy in work, he/she want to charge the phone quickly, here it comes the usefulness on wireless and faster charging. Every single persons use smart phone with different range of battery specification. Generally, battery capacity ranging from (1500-4500 mAh) [2]. While in smart phone charging and discharging of battery is major concerned for developers. As the usage of electronic devices is rapidly growing, the demand for longer battery life is also increasing. Lithium-ion battery are best suited till now, but technology are stepping up to new level, research are going in the field of Nanomaterial for the replacement of battery. One such material we used in our project is Super capacitor. Super-capacitor are the batter option as if compare with conventional battery. Traditional batteries are of chemical compositions, it stores the energy in the form of

chemical energy and further chemical energy is converted into electrical energy for various usage. Battery used in mobiles phones are rechargeable battery and can be used many times to charge and discharge. A lithium-ion battery nearly takes (1.30-2 hrs.) to get fully charged. Charging time depend on the charging current given to battery with constant terminal voltage [3]. Depend on the percentage of rated current given to charge the phone, it is classified into three types:

1. Slow Charging
2. Fast Charging
3. Quick Charging

When the charging current is in the range of 8-12 percentage of rated current of the battery then mobile phone takes 6-8 hours' time to get fully charged. This kind of charging is called slow charging [4].

While in fast charging, the charging current ranges from 45-70 percentage of current rating of battery, this is methodology we follow in normal charging which takes approximately two hours to full charge the battery.

Whereas in quick charging the charging current is equal to or higher than that of rated current of battery, which is not preferable in general because it reduce battery life span as well durability [5].

In this fast and high-technological world spending hours and hours for charging the gadgets is not acceptable. We consider, this is the one of big issue in the field of technology, thus introducing some methodology to overcome it. We use wireless power transmission (WPT) circuit to transmit power without any connection, this power transmission circuit consist of two circuit namely transmission circuit and receiver circuit [6].

After power delivered by transmitter circuit, receiver circuit receive it in the form of AC power, which is converted by rectifier to DC power and DC-DC stabilizer will provide a constant DC output. This DC power is used to charge the super capacitor very quickly say for 2-3 minutes. We can use super capacitor bank by placing the capacitors in series or parallel to improve total capacity of bank. This charged super capacitor can charge mobile phone very effectively [7].

2. LITERATURE SURVEY

2.1. Ultra-Capacitor

Ultra-capacitor is an invention of Nano science, this look like a simple capacitor but the property associated with the ultra-capacitor is very different. Supercapacitor is another name for ultra¬capacitor. Ultra-capacitor are two types, those are pseudo capacitor and double layer capacitor. Their charge storing capacity is very high like a battery and their structural configuration is also somewhat like batteries. It is having two electrodes positive and negative which are separated by separator. These electrodes are manufactured by porous material [8].

Supercapacitor is confined to deliver limited voltage around 2.5 to 2.8v, higher rating is possible but it may decrease the service life of supercapacitor, so for various application, according to our voltage requirement we have the flexibility to connect supercapacitor in parallel or series.

2.2. Block Diagram Description

Figure 1 shows describe the Super Capacitor Block diagram.

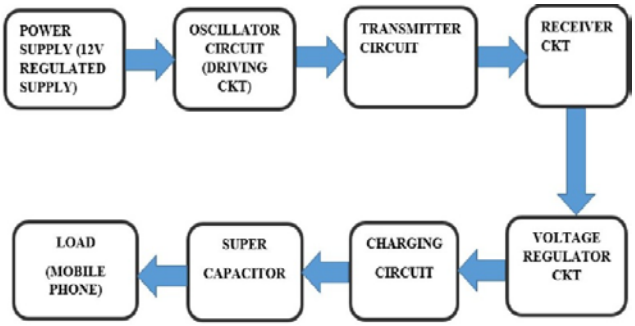

Figure 1. Describe the Super Capacitor Block diagram

2.2.1. Regulated Power Supply

For supplying the power to the circuit, regulator power supply is used. Circuit is receiving 12V DC voltage.

2.2.2. Oscillation Circuit

To transfer the power from one circuit to another we used inductive coupling principle. Here we used two basic circuit one is transmitter and receiver circuit. Transmitter circuit have two (n-channel) MOSFET namely T1 & T2. It is incorporated in the circuit to generate high frequency at transmitter circuit. Driving circuit is required for switching of MOSFET. Push pull driving circuit is used to amplify voltage as well to produced high frequency approximately of 1.4 MHz [9].

2.3. Transmitter Circuit

Transmitter circuit is developed with 14mm diameter copper tube (magnet tube).It is a hollow Copper tube has 1turn in circular shape with the circle diameter of 250mm. It is design in such a way that it should have coil inductance of=0.674 mH. Circuit of transmitter can show in Figure 2.

$$L = \frac{0.001 * N2 * \left(\frac{a}{2}\right)^2}{(114 * a) + (254 * l)} H \quad (1)$$

a = Diameter of coil
l = length of coil
N= Number of turns

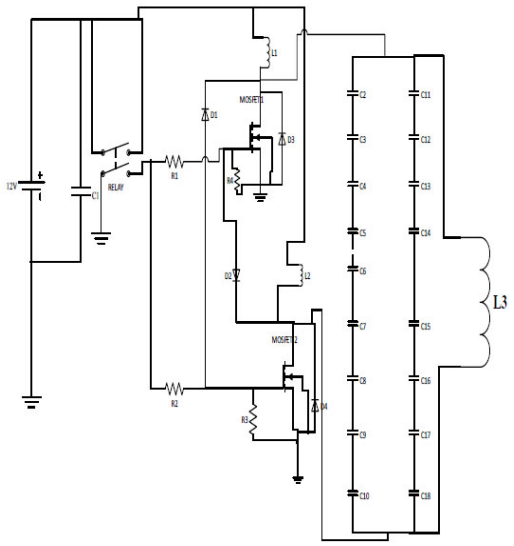

Figure 2. Circuit of transmitter

2.4. Receiver Circuit

Receiver circuit also has been constructed by using copper tube. Receiver circuit consist of three part, first one is copper tube then rectifier and voltage regulator Integrated Circuit. AC current which flows in the transmitter coil produces alternative magnetic flux, whenever Receiver circuit is closer to transmitter circuit, nearly 15-20 cm, magnetic flux cut the receiver tube. Hence by Faraday's second law of electromagnetics, an EMF is developed in receiver circuit and due to close loop, current flow in the receiver coil. This AC is converted by rectifier in to constant pulsating DC. After that rectifier capacitor are used to decrease noise contents as well as ripple content in DC. LM317T IC is used to stabilize the output filter [10]. Circuit of receiver can show in Figure 3.

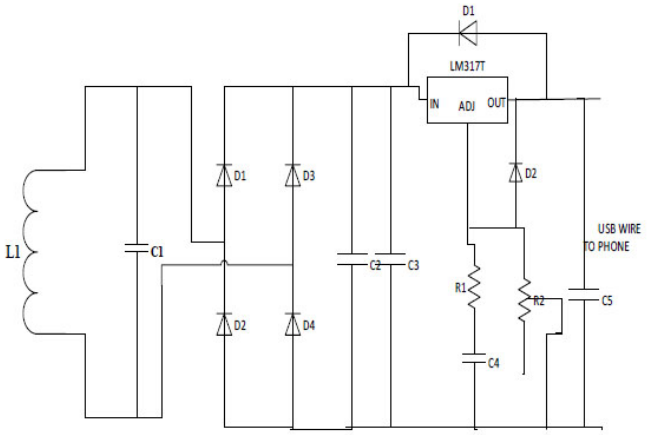

Figure 3. Circuit of receiver

3. WIRELESS POWER TRANSFER AND ITS EFFECT WITH DISTANCE VARIATION

Principle of wireless power transmission Wireless power transmission is possible by transmitter and receiver coils.

3.1. Transmitter coil

According to Biot-savart law magnetic flux density generated by flow of charge is given by:

$$B = -\frac{\mu_o}{4\pi}\oint_0^I \frac{ldl * e1}{r^2} \quad (2)$$

Where:
B = Magnetic field generated at a distance of 'r' due to current flowing in the wire or circular tube, μ_o = Magnetic constant, dl = It is a smallest vector element of a wire or differential length of wire in the direction of conventional current, I = Current flowing in the wire, the expression for magnetic field due to circular current carrying coil along its axis is given by this equation:

Figure 4. show the magnetic field at the axis of circular coil:

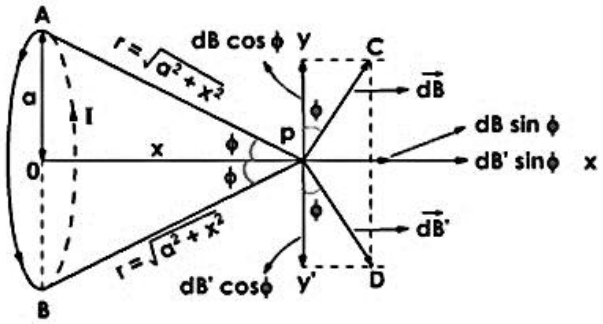

Figure 4. Magnetic field at the axis of circular coil

This is how magnetic field is produced by transmitter coil and magnetic field is coupled by receiver coil at a distance of (x) [11].

$$B = \frac{\mu_o INa^2}{2(x^2 + a^{2)^{\frac{3}{2}}}} Tesla \quad (3)$$

3.2. Receiver coil

Time varying magnetic field generated by transmitter coil crossing the receiver coil hence due to this EMF is set up in secondary coil and a circulating current will flow in the receiving coil. It is based on the faraday principle.

$$V(t) = -\frac{d\Phi m(t)}{dt} \quad (4)$$

Table 1. Showing the Variation in Receiver Coil Voltage with Respect to Distance

Input voltage (Volt)	Transmitter coil frequency (MHz)	Receiver coil Frequency (MHz)	Distance (cms)	Primary voltage (volt)	Secondary voltage (volt)
12	4.3	1.4	2.5	15	4.6
12	3.8	1.4	5	15	3.8
12	3.2	1.4	7	15	3.6
12	2.8	1.4	16	14.6	3
12	2.8	1.4	21	14.6	2.2

As per the experiment conducted these are some observation we obtained. Table 1 shows the distance variation effect on receiving coil voltage, as well as it also shows variation in primary voltage and frequency.

Observations:

a. Voltage output at receiving end getting lower as distance between the two coils is increase.
b. There is a certain change in primary frequency we observed while changing the distance.
c. Receiver coil frequency remains almost constant.

4. HARDWARE IMPLEMENTATION

Compilation of hardware set up is shown in Figure 5 and Figure 6 here the transmitter and receiver circuit tube inner diameter, length and circular diameter is measured for further calculation.

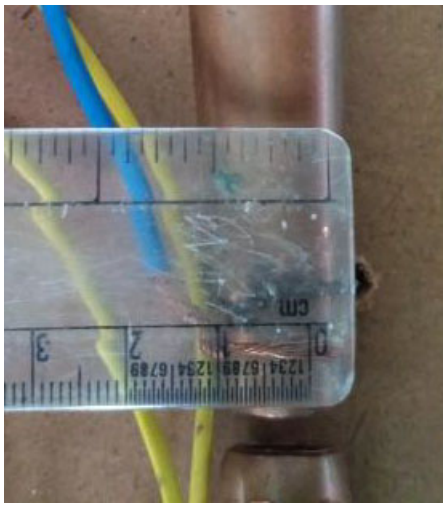

Figure 5. Transmitter and receiver tube (17mm diameter) and diameter of coil is 260mm

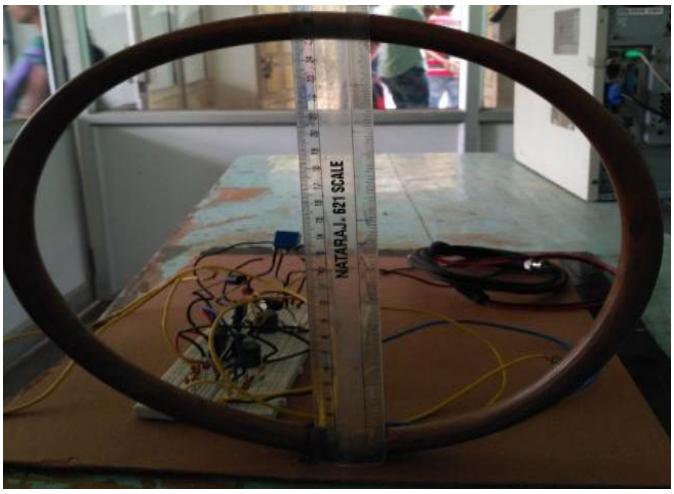

Figure 6. Transmitter and receiver tube (17mm diameter) and diameter of coil is 260mm

5. CHARACTERSTICS OF SUPER CAPACITORS

Capacitors are used to store the energy in the form of electric field, conventional capacitors stores energy in parallel plates separated by dielectric medium. Movement of charge carrier will store the energy, electrons from one plate is being removed and deposited to another plate, hence a charge separation occurs,

and a potential difference is created between two metal plates. This potential difference can be subjected to external circuit. Charge storing capacity can be increased by changing the dielectric medium in between the plates; there are many materials which can be used as dielectrics between the plates to increase the storage capacity of capacitor, example aluminum electrolytic and tantalum oxide film as dielectric. That was all about a capacitor, coming to the electric double layer capacitor; it does not have any dielectric medium. Instead of that, it uses a phenomena knows as electric double layer. In ultra-capacitor, the effective thickness of the dielectric is ultra-thin and as carbon is porous in nature, the surface area is quite high which makes it very high capacitive. In general, when two different phases comes in contact with each other then they settle in array of positive and negative charges at the boundary. At the point of contact between the surface of conductor and the electrolyte, different polarity of charges occurs. This array is called as Electrical Double layer. The reason behind the high capacitance of an ELDC is due to charge stored at the interface, by charging electric field between anode and cathodes. Based on the electrodes, super capacitor family is divided into three family members.

Simulation of wireless power transfer circuit is shown in Figure 7. Conduction and frequency generation of power MOSFET T1 & T2 is shown in Figure 8. Inductive coupling waveform (transmitter and receiver side) is shown in Figure 9. Switching frequency of MOSFET T1and T2 is shown in Figure 10.

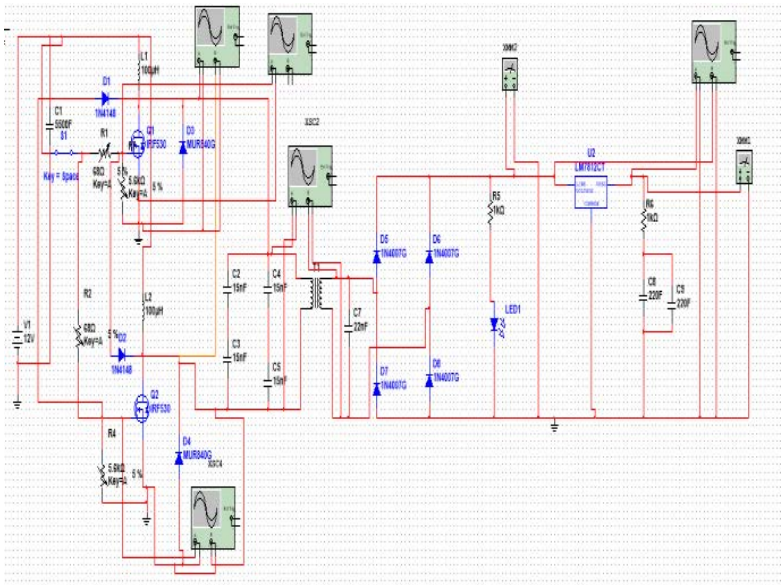

Figure 7. Simulation of wireless power transfer circuit

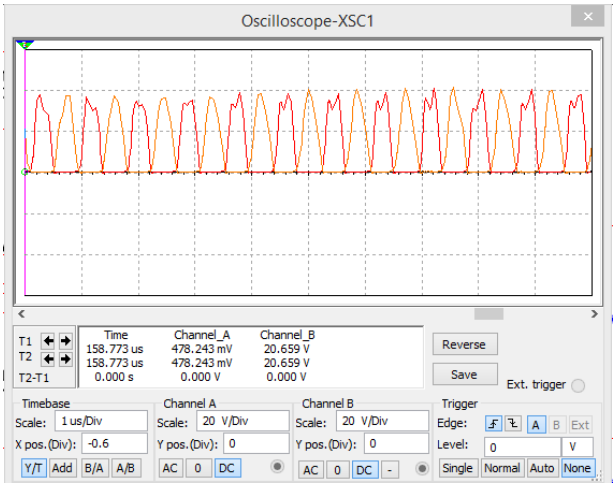

Figure 8. Conduction and frequency generation of power MOSFET T1 & T2

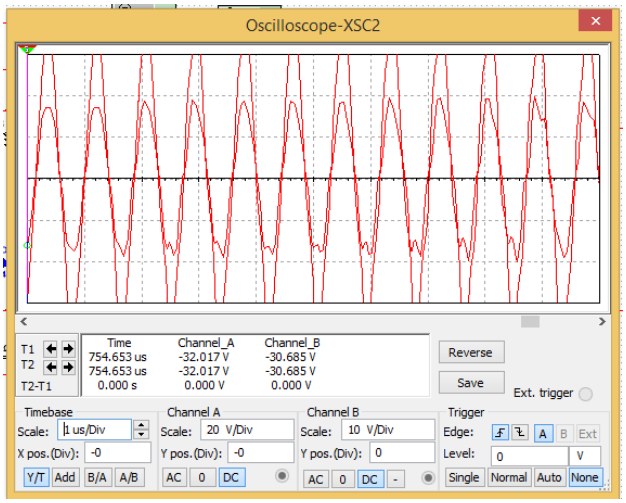

Figure 9. Inductive coupling waveform (transmitter and receiver side)

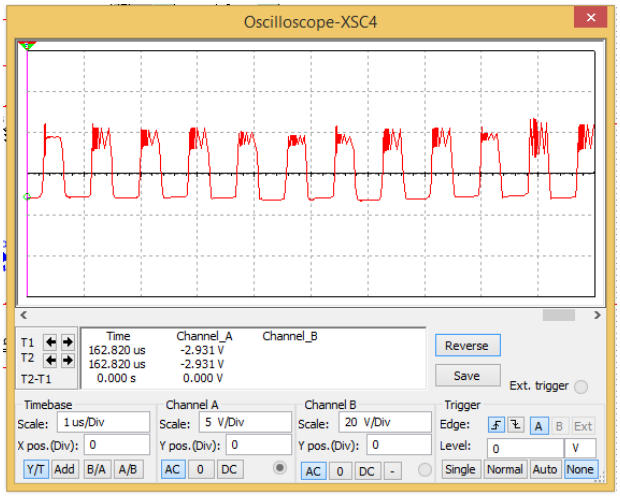

Figure 10. Switching frequency of MOSFET T1and T2

6. CONCLUSION

These days every individual is using mobile phone, battery is the main storage element for running it. Phone battery should have long durability and it should be charged very fast, but when we talk about fast charging there is always a chance to have lower battery life. Users are spending lot of time to charge phones. By super capacitor as new energy storage element, charging time of these phones can be decreased. Super capacitor will charge fast as well as it will have more discharging time by the introduction of boost converter in the discharging circuit. It can discharge in more time compare to battery. Even super capacitors have more life span than battery. So, if we charge our mobile with bank of super capacitor, it can be charged within minutes.

REFERENCES

[1] David W Baarman "Understanding wireless power", Director of Advanced Technologies, Fulton Innovation Joshua Schwannecke, Research Scientist, Fulton Innovation, December 2009.
[2] Raman. S.R "Review of charge equalization schemes for Li-ion battery and super-capacitor energy storage systems" IEEE Conference Publications ICAECC, pp. 1 – 6, 2014.
[3] J.Manikandan, R.Mohana Priya, S.Pavithra, D.Sarathkuma "Rapid smart phone charging using supercapacitor" published in International journal of advanced research in Electrical, electronics and Instrumentation Engineering. Vol. 4. Issue4, April 2015.

[4] Balkrishna, Piyush , Ameya , Suyog and Prof. Ankur, “Wireless mobile charging using super capacitor” published in International Journal of Application or Innovation in Engineering & Management (IJAIEM) Volume 5, Issue 2, February 2016.
[5] Do Lam Mung, Kyaw Soe Lwin, Hla Myo Tun “Design and construction of wireless charging system using inductive coupling” published in international journal of scientific & technology research. Volume 4, Issue 06, June 2015.
[6] Marin S. Halper & James C. Ellenboge, “Supercapacitors: a brief overview”, book, March 2006.
[7] Hamasaki. S “Control of power leveling unit with super capacitor using bidirectional buck/boost DC/DC converter” IEEE Conference Publications, International Conference on Renewable Energy Research and Applications pp. 1 – 6 2012.
[8] N. Kumarasabapathy and P. S. Manoharan, MATLAB Simulation of UPQC for Power Quality Mitigation Using an Ant Colony Based Fuzzy Control Technique, Scientific World Journal, Hindawi Publishing Corporation, Volume 2015, pp 1-9.
[9] Goutam Kumar Malla, Simulation Study of UPQC and Active Power Filters for a NonLinear Load, International Journal of Current Engineering and Technology , Vol.5, No.1 (Feb 2015), pp 375-384.
[10] Chia-Hsiang Lin ”Fast charging technique for Li-Ion battery charger” IEEE Conference Publications ICECS, pp. 618 – 621 2008.
[11] Chia-Hsiang Lin ”Fast charging technique for Li-Ion battery charger” IEEE Conference Publications ICECS, pp. 618 – 621 2008.