ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Rapid Smart Phone Charging Using Super Capacitor

J.Manikandan*, R.Mohana Priya*, S.Pavithra*, D.Sarathkumar#

Assistant Professor, Dept. of EEE, Kongu Engineering College, Perundurai, Tamilnadu, India#

UG Student, Dept. of EEE, Kongu Engineering College, Perundurai, Tamilnadu, India *

ABSTRACT: The growing technology introduces many electronic gadgets in day to day life. As like population increases the usage of these gadgets also increases in a wider scale. All these gadgets are powered up by the batteries. Though the power consumed by these electronic gadgets is very minimum when compared to that of other electrical equipments the time spends in charging these electronic gadgets is quite high. Mobile phones are the very popular electronic gadget of all others. A Survey says that the number of mobile phones is nearing the human population in earth. Our objective is to create energy storage system for electronic gadgets particularly for mobile phones that would charge in few seconds. We make use of a super capacitor to achieve this objective. A super capacitor is a device that charges and discharges energy like batteries. But the difference is super capacitor charges in very minimum time period say, in few seconds due to its low internal resistance. The super capacitor has a greater life time than that of battery. It is 5000 duty cycle for a super capacitor compared to the duty cycle of lithium ion battery of 1000 duty cycles. Over charging will not degrade the life span of super capacitor and do not cause any hazardous problem due to overcharging. But the batteries will be exploded once it is over charged or input voltage is higher than that of the rated voltage. Super capacitor have better characteristic than that of a battery except the potential difference during the discharging of energy. The voltage is constant in a battery while discharging, whereas in a super capacitor the voltage level drops when it starts to discharges. This can be compensated by designing a DC-DC boost converter that maintains a constant output voltage irrespective of the change in voltage of super capacitor during discharge.

KEYWORDS: super capacitor, quick charging, DC-DC boost converter.

I.INTRODUCTION

The advancement in Science and technology has introduced many Electronic devices in the day to day life of Human beings. Electronic Gadgets like mobile phones became a necessity in this advanced world. These Electronic Gadgets use batteries as their Energy storage system. Lithium ion, nickel cadmium are different type of commonly used batteries for this purpose. This creates a Global market for the production of batteries. A battery is a device that converts the Chemical energy into Electrical energy. Batteries have three parts, an Anode (-), a Cathode (+), and the electrolyte. The cathode and anode (the positive and negative sides at either end of traditional battery) are hooked up to an Electrical circuit. The chemical reactions in the battery cause a build up of Electrons at the anode. The batteries used in these Electronic devices are rechargeable i.e. it can be charged and discharged many times. The charging time of a battery depends on the charging current given to the battery. It is essential to provide 10 percentage of the rated current of battery as charging current to initiate the charging of battery. However the voltage should be maintained same as that of battery rating. The charging of battery can be classified into three types based on the charging time of the battery. When the charging current is 10 percentage of the current rating of the battery the type of charging is termed as **slow charging**, which requires 10 hours to fully charge a battery. When the charging current is 40-70 percentage of the current rating of the battery the type of charging is termed as **fast charging**, which is normally adopted method of charging the battery. When the charging current is same or higher than that of the current rating of the battery the type of charging is termed as **quick charging**, which is not preferred as it reduces the life time of battery. However the charging of battery in mobile phones is around 120 to 150 minutes as the battery current rating hardly exceeds 1500 mAh. The income of Smartphone increased the rating of batteries used in the mobiles as it requires more power to run all the application supported by the mobile. In this fast moving world spending more than an hour for charging the mobile phone is a big issue and people are not interested to spend that much time for a mobile to charge. People are

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

looking an alternative solution for quick charging their mobiles and other electronic gadgets without sacrificing the life, performance and standard of the product.

II. LITERAURE REVIEW

Batteries are the commonly used energy storage system in many of the electrical systems. A battery is a cell that converts chemical energy into electrical energy. A typical battery consists of electrode and electrolyte. A mobile phone battery makes use of lithium ion battery for their energy storage purpose. Their life span is 1000 duty cycle. One duty cycle is the complete period of a battery to charge and discharge. Normally batteries are charged at 60-70 percent of their rated current. This type of charging is termed as fast charging. But it is not possible to charge a battery within an hour without any compromise in the performance. It is practically possible to charge a battery higher than of its rated current but it leads to degradation and sometimes explosion of battery [3]. The primary objective is to decrease this charging time of the energy storage system. To meet this requirement we have proposed to replace batteries by super capacitor whose internal resistance is low [2]. Thus to design an energy storage system for mobile phones using super capacitors that charges in few seconds.

III.SUPER CAPACITORS

In order to reduce the charging time of mobile phone, we have used the super capacitor bank. A super capacitor is a specially designed capacitor which has a very large capacitance. Super capacitors combine the properties of capacitors and batteries into one device. A super capacitor could be charged within few seconds like a capacitor and discharges like a normal battery. This property of super capacitor makes the possibility of replacing the normal battery used in mobile phone with super capacitors. By using the super capacitors as energy storage device for mobile phone it is possible to mobile that charges in few seconds. Super capacitors are electronic devices which are used to store extremely large amounts of electrical charge. They are also known as double-layer capacitors or ultra capacitors. Instead of using a conventional dielectric, super capacitors use two mechanisms to store electrical energy. They are Double-layer capacitance and pseudo capacitance. Double layer capacitance is electrostatic in origin, while pseudo capacitance is electrochemical, which means that super capacitors combine the workings of normal capacitors with the workings of an ordinary battery. Capacitances achieved using this technology can be as high as 12000 F. In comparison, the self-capacitance of the entire planet Earth is only about 710 µF, more than 15 million times less than the capacitance of a super capacitor. While an ordinary electrostatic capacitor may have a high maximum operating voltage, the typical maximum charge voltage of a super capacitor lies between 2.5 to 5.5 volts. Super capacitors are polar devices, meaning they have to be connected to the circuit the right way, just like electrolyte capacitors. The electrical properties of these devices, especially their fast charge and discharge times, are very interesting for some applications, where super capacitors may completely replace batteries.

III. CHARACTERISTICS OF SUPER CAPACITORS

In a conventional capacitor, energy is stored by the removal of charge carriers, typically electrons from one metal plate and depositing them on another. This charge separation creates a potential between the two plates, which can be harnessed in an external circuit. The total energy stored in this fashion is a combination of the number of charges stored and the potential between the plates. The former is essentially a function of size and the material properties of the plates, while the latter is limited by the dielectric breakdown between the plates. Various materials can be inserted between the plates to allow higher voltages to be stored, leading to higher energy densities for any given size. For example aluminium electrolytic and tantalum electrolytic capacitors, use an aluminium oxide film and a tantalum oxide film as the dielectric, respectively. In contrast, Electric Double Layer Capacitors do not have any dielectrics in general, but rather utilize the phenomena typically referred to as the electric double layer. In the double layer, the effective thickness of the "dielectric" is exceedingly thin, and because of the porous nature of the carbon the surface area is extremely high, which translates to a very high capacitance. Generally, when two different phases come in contact with each other, positive and negative charges are set in array at the boundary. At every interface an array of charged particles and induced charges exist. This array is known as Electric Double Layer. The high capacitance of an EDLC arises from the charge stored at the interface by changing electric field between anode and cathodes. Super capacitors have charge and discharge times comparable to those of ordinary capacitors. It is possible to achieve high charge and

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

discharge currents due to their low internal resistance. Batteries usually take up to several hours to reach a fully charged state – a good example is a cell phone battery, while super capacitors can be brought to the same charge state in less than two minutes. The specific power of a battery or super capacitor is a measure used to compare different technologies in terms of maximum power output divided by total mass of the device. Super capacitors have a specific power 5 to 10 times greater than that of batteries. For example, while Li-ion batteries have a specific power of 1–3kW/kg, the specific power of a typical super capacitor is 10kW/kg. This property is especially important in applications that require quick bursts of energy to be released from the storage device. Super capacitor batteries are safer than ordinary batteries when mistreated. While batteries are known to explode due to excessive heating when short circuited, super capacitors do not heat as much due to their low internal resistance. Shorting a fully charged super capacitor will cause a quick release of the stored energy which can cause electrical arcing, and might cause damage to the device, but unlike batteries, the generated heat is not a concern. Super capacitors can be charged and discharged millions of times and have a virtually unlimited cycle life, while batteries only have a cycle life of 500 times and higher. This makes super capacitors very useful in applications where frequent storage and release of energy is required.

IV. DC-DC BOOST CONVERTERS IN THIS ENERGY STORAGE SYSTEM

Both electrostatic and electrochemical energy storage in super capacitors are linear with respect to the stored charge, just as in conventional capacitors. The voltage between the capacitor terminals is linear with respect to the amount of stored energy. Such linear voltage gradient differs from rechargeable electrochemical batteries, in which the voltage between the terminals remains independent of the amount of stored energy, providing a relatively constant voltage. super capacitor is not voltage constant like lithium ion battery. During the discharge time the voltage level of super capacitor drops. But to power any electronic device it is necessary to maintain the same voltage. So a boost converter is designed to maintain a constant output voltage. A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple

V.SELECTION OF SUPER CAPACITOR

It is very important to choose a super capacitor of desired rating for any energy storage system so as to provide the same performance of batteries that could do in the system. The energy stored in capacitor is measured in farad, unit of capacitance. While the energy stored in the batteries are measured in watts/hour. So it is important to establish a relation between energy in terms of watts/hour and capacitance. Generally the batteries are rated in ampere hour which is an important parameter in calculating charging and discharging time of the battery. The equation (5.1) relates this capacitance and ampere hour.

$$[(V_{min} + V_{max})/2]^* (F/3600) = Ah \quad \text{..... (5.1)}$$

Here

F= farad; Ah= Ampere hour

The Fig.1, shows the various capacitance equivalents of different rating of lithium ion battery used in mobile

.

S.NO	BATTERY RATING (mAh)	EQUIVALENT CAPACITANCE (Farad)
1	1000	782
2	1250	978
3	1500	1173
4	1800	1408
5	2100	1643

Fig.1 battery and super capacitor ratings

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

VI.RAPID ENERGY STORING SYSTEM

The block diagram consisting of various blocks in the proposed system is shown in the Fig. 2 It consists of totally five blocks starting from a step down transformer in power supply and ends with a load i.e. mobile.

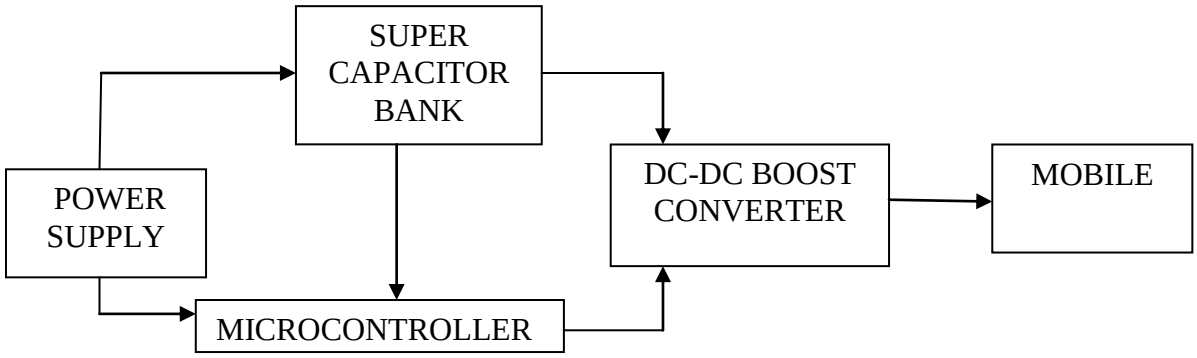

Fig. 2 proposed block diagram

The super capacitor should be charged at the desired voltage level it is rated. At the same time the microcontroller should also be biased. A typical microcontroller requires a bias voltage of 5 volt. The super capacitor used in the project is rated as 5.5 volt. So single power supply of constant 5 volt DC can be designed for both charging the super capacitor and biasing the microcontroller.

VII.WORKING OF THE CIRCUIT

The super capacitor bank is charged using the power supply designed. The power supply unit consist of step down transformer that step downs the AC voltage from 230 V to 12 V. It is then rectified using bridge rectifier and a voltage regulator is used to obtain a constant DC output from the supply. The voltage regulator LM7805 is used which gives a constant output of 5 V. The super capacitor due to its low internal resistance charges so quickly say in few seconds. Once the charge is stored in super capacitor it starts to discharge. The mobile is connected across this super capacitor, now the mobile utilizes this discharge current from the super capacitor for its Working. As mentioned earlier the super capacitors are not voltage constant, once it starts to discharge the voltage level decreases. So the super capacitor bank is connected to the DC-DC boost converter. The isolation circuit consists of opto coupler which provides isolation between the controller and the converter. The converter makes use of MOSFET IR840 switch and opto coupler PC817D. The converter maintains a constant output voltage of 3.8v irrespective of the decrease in voltage in super capacitor while discharging.

VIII. RESULTS AND DISCUSSION

The super capacitors are available from 1 farad to 3000 farad. It is difficult to find the exact super capacitor equivalent to the battery. But using the available range of super capacitor nearer to the value calculated will not be affecting the device and has no hazards on the user. We have selected a super capacitor of rating 4 farad and 5.5 volt. We have made a super capacitor bank by connecting super capacitors in parallel. Four super capacitors are connected in parallel of each 4 farad. The 16 farad super capacitor bank that we have used gets fully charged in 130 seconds. The Fig. 3 shows the charging time and discharging time of super capacitor bank. The x axis represents the charging and discharging of super capacitor. And the y axis represents the time in seconds. From the graph it can be visualised that how quick the super capacitor can be charged. The charging time of super capacitor in few seconds comparing to the charging of convention batteries in hours with the same backup time can be reached, when equivalent capacitance to that of battery is replaced.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Scale
In y axis 1 unit=500s

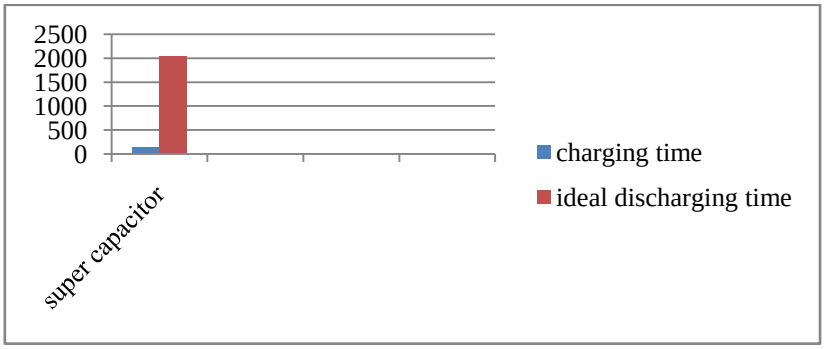

Fig. 3 one duty cycle of SC bank

The discharge time varies according to the type of application running on the mobile. The Fig. 4 shows the discharging time of mobile, when different applications are running. Mobile has numerous applications; the discharge of energy depends on the type of application running on the mobile.

Scale
In y axis 1 unit=500s

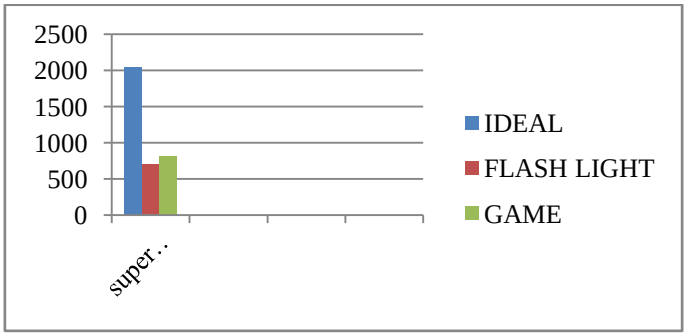

Fig. 4 discharge time of mobile

From the graph it can be seen that the mobile phone last for 34 minutes when the phone is kept ideal, 12 minutes when the flash light in the mobile is running and 14 minutes when the user plays games in the mobile.

IX.CONCLUSION

The usage of mobile phones is increases day by day. The primary requirement of these mobile phones is energy storage systems. All types of mobile phones make use of batteries as their energy storage system. People spent lot of time in charging of these batteries. By using the super capacitors as an energy storage system a lot of time can be saved in charging them. Not only to save the time in charging, but also to avoid many hazardous things a battery can be replaced by a super capacitor. Super capacitor has a long life time than that of normal batteries. Mobile phones use processor for its different applications in the mobile. If the same processor is used for converter, the size of the system will be reduced. And the weight of the super capacitor is lesser than of a battery of same energy storing capacity so the overall device weight can be reduced. If not the power banks used nowadays for charging mobile phones can be made using this super capacitor. So it is easy to develop a single power bank that can be charged in few seconds and can charge all type of mobile phones through a single USB cable. Maximum number of portable electronic devices and electronic gadgets use batteries as their energy storage system. Super capacitor finds its application in all these devices.

.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

REFERENCES

[1] 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
[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] Chia-Hsiang Lin "Fast charging technique for Li-Ion battery charger" IEEE Conference Publications ICECS, pp. 618 – 621 2008