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Design and Implementation of Fast Charging Universal Power Bank Using Super Capacitor

Asst. Prof. Mr. K. Sathiyaraja, M. Sasikala, R. Shobhana, R. Thamil Ilakkiya, R. Manoj
Department of Electronic and Communications Engineering,
Annai Mathammal Sheela Engineering college, Erumapatty,
Tamilnadu, India.
sathiya.raja97@gmail.com, sasikalasasikala6659@gmail.com, shobhanaramasamy@gmail.com, sujithamil23@gmail.com, manojrajendiran@gmail.com

Abstract- **Portable power banks are comprised of battery in a case with a circuit to control power flow. Power banks are becoming increasingly popular because the battery life of phones, tablets and portable media players is exceeded by the number of time gadgets used in a day. In this project, the design and implementation of universal power bank using super capacitors as a charge storage device is presented. Existing power banks use batteries to store charges and it takes a long time to charge completely. In this work, batteries are replaced with super capacitors to take advantage of its quick charging and slow discharging feature. Super capacitors are charged using charging and regulation circuit. An output regulator circuit delivers the necessary power for charging portable devices. A display is also implemented using a Atmega microcontroller for monitoring. Battery technologies are well established and widely used technology but they offer several disadvantages like weight, volume, large internal resistance, poor power density, poor transient response. On the other hand, due to advancement in the material and other technology, Super capacitor or Ultra capacitors or Electrostatic Double Layer Capacitor (EDLC) are a most promising energy storage device. They offer a greater transient response, power density, low weight, low volume and low internal resistance which make them suitable for several applications.**

Keywords- **power banks , Ultra capacitors or Electrostatic Double Layer Capacitor (EDLC), etc**

I. INTRODUCTION

Super capacitor is an emerging technology in the field of energy storage systems that can offer higher power density than batteries and higher energy density over traditional capacitors.

Super capacitor will become an attractive power solution to an increasing number of applications, such as renewable energy power generation, transportation, power system and many others, because of its advantages which include high charge/discharge current capability, very high efficiency, wide temperature range, etc.

In this project, the advantages and disadvantages of super capacitor are discussed and some critical technologies for designing supercapacitor energy storage system are presented in detail. Finally, the role of the super capacitor in universal power storage system is discussed and a supercapacitor based Universal Portable Power Bank (UPPB) for charging the electronics system.

Super capacitors (SCs), also known as electric double-layer capacitors or ultracapacitors, are energy storage devices that store electrical energy without chemical reactions. Energy storage mechanisms that do not require chemical reactions provide several advantages over traditional secondary batteries such as lead-acid, Ni-Cd, Ni-MH and lithium-ion batteries (LIBs) in terms of cycle life performance, power capability, coulombic efficiency and low temperature performance.

In addition to these superior electrical properties, it is easier to estimate the state of charge (SoC) for SCs than that for secondary batteries because the terminal voltage of SCs is inherently proportional to the SoC. In order to meet load variations, SCs are widely used as auxiliary power sources that complement main energy sources such as secondary batteries and fuel cells.

In such applications, SCs act as electrical power buffers with large power capability. SCs are currently considered to be unsuitable as main energy storage sources because their specific energy values are lower than those of secondary batteries. However, with the emergence of new technologies and new chemistries that can lead to increased specific energies and reduced cost, they are considered to be attractive alternatives to main energy storage sources, especially because of their long life. However, SCs have some major drawbacks originating from their inherent electrical properties.

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These are as follows:

- The specific energy of SCs is lower than that of traditional secondary batteries.
- Cell/module voltages of SCs in a series connection need to be eliminated since cell/module voltage imbalance may result in premature irreversible deteriorations and/or decrease in available energy.
- Since the specific energy of SCs is low, energy stored by SCs should be delivered to loads as efficiently as possible in order to avoid energy wastage.
- Terminal voltages of SCs vary widely with charging/ discharging processes. Power converters having wide voltage ranges are required to power loads within a particular voltage range.

II. SUPER CAPACITORS AS MAIN ENERGY STORAGE SOURCES

In general, the specific energy of SCs is lower than that of traditional secondary batteries. For example, specific energies of lead-acid and alkaline batteries (such as Ni-Cd and Ni-MH batteries) are 20–40 and 40–80 Wh/kg, respectively, and those of LIBs are at least 150 Wh/kg.

On the other hand, the specific energy of conventional SCs does not exceed 10 Wh/kg. Lithium-ion capacitors (LICs), which are newly emerging SCs having a new chemistry, offer values less than 30 Wh/kg, which are comparable to those of lead-acid batteries but remain lower than other battery chemistries. LICs can match lead-acid batteries but their costs are not comparable.

Meanwhile, there is still a large gap between LIBs and SCs (including LICs) in terms of specific energy, and therefore, SCs are usually considered unsuitable as main energy storage sources. However, SCs are considered to be potential alternative main energy storage sources considering their net specific energy, which is defined as;

$$\text{Net Specific Energy} = \text{Specific Energy} \times \text{Depth of Discharge}$$

as well as their cycle life performance. For example, in low-Earth orbit satellite applications, where a minimum service life of three years is required for energy storage systems, three types of energy storage sources, (i) alkaline batteries, (ii) LIBs and (iii) SCs, are compared in terms of specific energy, depth of discharge (DoD) and net specific energy.Traditional secondary batteries for such satellites are operated with relatively shallow DoD of 20%–25%, allowing the life requirement to be fulfilled.

Therefore, the net specific energies of alkaline batteries are 8–20 Wh/kg, and similarly, those of LIBs are 30–50 Wh/kg, although LIBs offer high specific energies of 150–200 Wh/kg. On the other hand, SCs can be cycled with deep DoD values even for such long-term applications because their cycle lifeperformance is inherently excellent and is independent on DoD (as shown later). For LICs, the net specific energy reaches.

Table 1. Comparision between Alkaline battery,LIB and Super capacitor.

	Alkaline Battery (Ni-Cd, Ni-MH)	LIB	Supercapactor	
			Conventional	LIC
Specific Energy	40-80 Wh/kg	150-200 Wh/kg	< 10 Wh/kg	< 30 Wh/kg
Depth of Dischar	20-25%	20-25%	< 80%	< 80%
Net Specific Ener	8-20 Wh/kg	30-50 Wh/kg	< 8 Wh/kg	< 24 Wh/kg

Specific energy, depth of discharge and net specific energy for traditional secondary batteries and SCs for low-Earth orbit satellite applications.The above comparison focuses on alternative applications for the batteries with shallow DoD for long-term cycle life.However, for deep DoD applications where the batteries are almost fully discharged, SCs cannot match the batteries from the perspective of net specific energy and cannot be an alternative energy storage source. Thus, SCs are practical and most suitable as main energy storage sources for applications where the batteries are used with shallow DoDs to achieve long cycle lives.

III. BLOCK DIAGRAM OF PROPOSED SYSTEM

The objective of a power supply is to power the load with the proper voltage and current. The current must be supplied in a controlled manner and with an accurate voltage to a wide range of loads, sometimes simultaneously, all without letting changes in the input voltage or in other connected devices affect the output. Direct current (DC) occurs when the current flows in one constant direction.

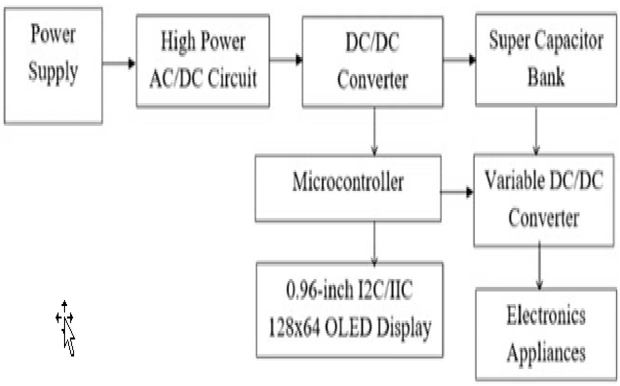

Fig 1.Block Diagram.

It usually comes from batteries, solar cells, or from AC/DC converters. DC is the preferred type of power for

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electronic devices. Alternating current (AC) occurs when the electric current periodically inverts its direction. AC is the method used to deliver electricity through power transmission lines to homes and businesses.

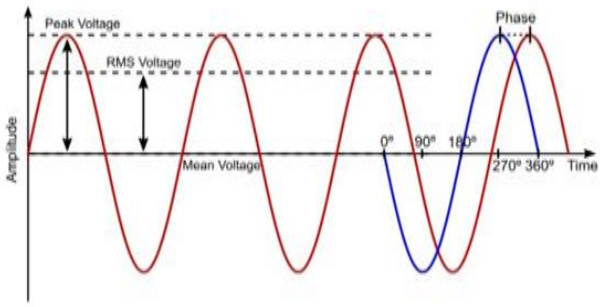

Fig 2. AC Waveform and Basic Parameters.

The first step in any power supply design is to determine the input current. And in most cases, a power grid's input voltage source is AC. The typical waveform for an alternating current is a sine wave .

1. Peak Voltage/Current:
The maximum value of amplitude the wave can reach.

2. Frequency:
The number of cycles the wave completes per second. The time it takes to complete a single cycle is called the period.

3. Mean Voltage/Current:
The average value of all the points the voltage takes during one cycle. In a purely AC wave with no superimposed DC voltage, this value will be zero, because the positive and negative halves cancel each other out.

4. Root-Mean-Square Voltage/Current: It is defined as the square root of the mean over one cycle of the square of the instantaneous voltage. Alternating current (AC) is the way electric power is transmitted from generating facilities to end users. It is used for power transportation because electricity needs to be transformed several times during the transportation process.

Electric generators produce voltages of about 40,000V, or 40kV. This voltage is then stepped up to anywhere between 150kV and 800kV, to reduce power losses when transporting electric current over long distances. Once it reaches its destination area, the voltage is stepped down to between 4kV and 35kV. Finally, before the current reaches individual users, it is reduced to 120V or 240V, depending on the location.

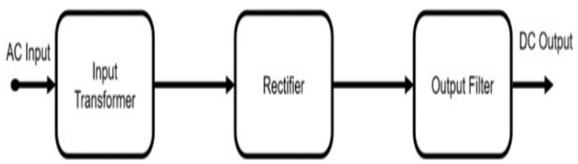

Fig no 2: Linear AC/DC Power Supply Block Diagram.

Traditional linear AC/DC power supply design has evolved over the years, improving in terms of efficiency, power range, and size—but this design has some significant flaws that limit its integration.

A huge limitation in a linear AC/DC power supply is the size of the transformer. Because the input voltage is transformed at the input, the necessary transformer would have to be very large and therefore very heavy. At low frequencies (e.g. 50Hz), large inductance values are necessary to transfer high amounts of power from the primary to secondary coil. This demands large transformer cores, which makes miniaturization of these power supplies practically impossible.

A linear AC/DC power supply uses linear regulators to maintain a constant voltage at the output. These linear regulators dissipate any extra energy in the form of heat. For low power, does not pose much of a problem. However, for high power, the heat that a regulator would have to dissipate to maintain a constant output voltage is very high, and would require adding extremely large heatsinks.

IV. CONCLUSION

In this project, some of the characteristics of the supercapacitors have been discussed which will be helpful to select supercapacitor and design energy storage system using it.

With high power density, short charging time, large discharging time, long life and environmentally friendly properties supercapacitor may be chosen as an alternative for battery or other energy storage devices. The project is designed for universal application. User can set the output voltage of the system base don electronic gadgets used. Applied AC is converted using AC-DC Converter and stored in supercapacitor. Then regulated DC-DC Converter is used for fix the voltage level of Electronics gadgets. The entire system is implemented using Atmega328 Microcontroller. The super capacitors are charged less than a Minutes.

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