

# Super Capacitor Based Operation of DC Motor

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**Abstract-** The need to seek an alternative source of power for fuel combustion based systems is imminent as pollution levels are increasing and an effective solution for this issue is to use battery as power source. This paper proposes the significant advantages supercapacitors have over traditional use of battery as power source by using a motor load as power output for technical comparison. The advantages and limitations of using both energy storage devices are explained thoroughly considering the charging and discharging of both of the devices.

**Keywords —** Supercapacitors, battery, energy storage, charging and discharging, comparison.

## I-INTRODUCTION

The science and technology advances lead to improvement of human life, but also creating of new crisis situation. Mankind is confronted with risks not seen earlier in human history. Global warming is one of the typical examples. Although majority of the experts studying climate changes claim global warming and fact that it is caused by human, there are also scientists that doubt those statements. An electric double-layer capacitor (EDLC) has relatively very high energy density. It is also known as super capacitor. Compared to normal capacitors of low farad value, the energy density of super capacitors is typically thousand times greater. In comparison with conventional batteries or fuel cells, EDLCs have a much higher pulse power density. In this paper the charging and discharging characteristics of super-capacitor and battery is shown to elaborate their advantages and limitations.

### 1. Supercapacitors:

Supercapacitors are different from normal capacitors because they are able to hold a much greater charge. Chemical reactions can take some time, but releasing the energy stored in capacitors can be done very fast. Super-capacitor is a novel solution for energy storage because of its high power and energy density which is almost 10 to 20 times higher than conventional capacitor and batteries. A recent development concern of global

warming has led to push towards electricity generation from renewable energy sources. With renewable energy power generation which is an inconsistent generation led to a time gap between supply and demand. Due to this there is an increase demand for energy storage. Among all the storage devices supercapacitors is relatively new energy storage system that provides higher energy density than dielectric capacitors and higher power density than batteries. Supercapacitor is composed of two electrodes immersed in electrolyte, and its porous dielectric separator prevents short circuit of two electrodes.

A super capacitor cell construction consists of two electrodes, a separator, and an electrolyte as illustrated in Figure 1 “Supercapacitor cell Illustration”. The electrodes consist of two parts, a metallic current collector and a high surface area active material. A membrane called the “separator” separate the two electrodes. The separator permits the mobility of charged ions but prohibits electronic conduction. This composite is subsequently rolled or folded into a cylindrical or rectangular form and stacked in a container. Then the system is introduced with an electrolyte, which is either a solid state, organic or aqueous type. The decomposition voltage of the electrolyte determines the maximum operating voltage of an super capacitor. Owing to the very small separation distance between the electrolytes, as well as the large effective surface of the active material, large capacitance magnitudes in terms of Farads are obtainable.

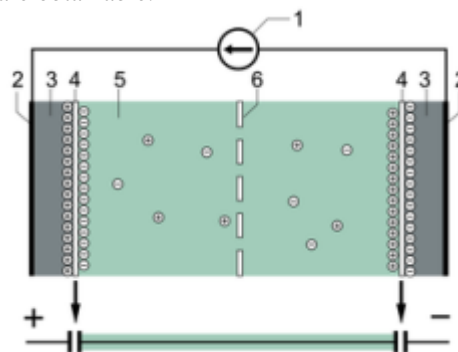


Fig1: Supercapacitor cell illustration

**2. Battery:**

The battery which uses sponge lead and lead peroxide for the conversion of the chemical energy into electrical power, such type of battery is called a lead acid battery. The lead acid battery is most commonly used in the power stations and substations because it has higher cell voltage and lower cost. The various parts of the lead acid battery are shown below. The container and the plates are the main part of the lead acid battery. The container stores chemical energy which is converted into electrical energy by the help of the plates.

Container – The container of the lead acid battery is made of glass, lead lined wood, ebonite, the hard rubber of bituminous compound, ceramic materials or molded plastics and are seated at the top to avoid the discharge of electrolyte. At the bottom of the container, there are four ribs, on two of them rest the positive plate and the others support the negative plates. The prism serves as the support for the plates and at the same time protect them from a short-circuit. The material of which the battery containers are made should be resistant to sulfuric acid, should not deform or porous, or contain impurities which damage the electrolyte.

Plate – The plate of the lead-acid cell is of diverse design and they all consist some form of a grid which is made up of lead and the active material. The grid is essential for conducting the electric current and for distributing the current equally on the active material. If the current is not uniformly distributed, then the active material will loosen and fall out. The composition of plates is shown in figure 2 “Lead Acid battery illustration”.

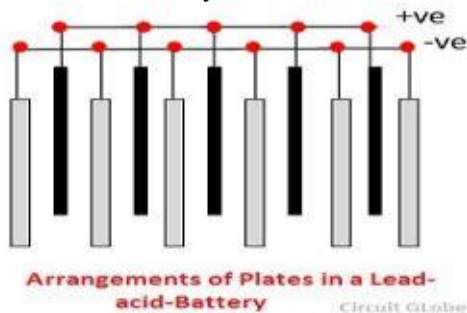


Fig 2: Lead Acid battery Illustration

Active Material – The material in a cell which takes active participation in a chemical reaction (absorption or evolution of electrical energy) during charging or discharging is called the active material of the cell. The active elements of the lead acid are Lead peroxide (PbO<sub>2</sub>), Sponge lead, Dilute Sulfuric Acid (H<sub>2</sub>SO<sub>4</sub>). The lead peroxide and sponge lead, which form the negative and positive active materials have the little mechanical strength and therefore can be used alone.

Separators – The separators are thin sheets of non-conducting material made up of chemically treated

leadwood, porous rubbers, or mat of glass fiber and are placed between the positive and negative to insulate them from each other. Separators are grooved vertically on one side and are smooth on the other side.

Battery Terminals – A battery has two terminals the positive and the negative. The positive terminal with a diameter of 17.5 mm at the top is slightly larger than the negative terminal which is 16 mm in diameter. A simple comparison of the two power sources are presented below in table 1.

Table 1: Comparison

Supercapacitor	Battery
Long cycle life.	Limited cycle life.
High load current.	Voltage and current limitations.
Short charging time.	Long charging time.
Excellent temperature performance.	More temperature sensitive than capacitors.
Low specific energy.	High power density.
Linear discharge voltage.	Constant voltage that can be turned on/off.
High self-discharge.	Better leakage current than capacitors.
Low storage capability.	Good storage capability.

**II. METHODOLOGY**

**1. Overview:**

From the AC supply 230V will reach the regulator circuit. The purpose for it is to convert 230V AC to 5V DC. There will be a continuous supply of 5V DC to charge the supercapacitor and battery each at a time. When the supercapacitor and battery are charged to a value i.e.5V the power supply is switched off. The charging time of the super-capacitor is noted through the readings displayed on LCD of voltage regulator. After some readings are noted the **graph** of charging time along with the voltage is plotted for graphical representation. Thereafter a 6V DC motor is connected to the both power sources and results are observed.

The purpose of this is to show the advantage and disadvantages of supercapacitor over the battery source.

**2. Tests results of on charging both power sources:**

The capacitors were charged with a regulated power supply of 5V and observed it’s charging time up to 2.5V with the help of multi-meter. It took approximately 16 minutes to get fully charged.

The same experiment is conducted with a 4.5AH, 5V battery and its charging time is observed to be 6hrs. Test results are presented below in table 2. and the “Charging voltage characteristics” is shown in figure

Sr.No.	Supercapacitor Voltage (V)	Battery Voltage (V)	Time (min)
1	0.631	0	0
2	1.341	0.129	5
3	1.919	0.186	11
4	2.279	0.265	14
5	2.512	0.373	16

Table 2: Test Results

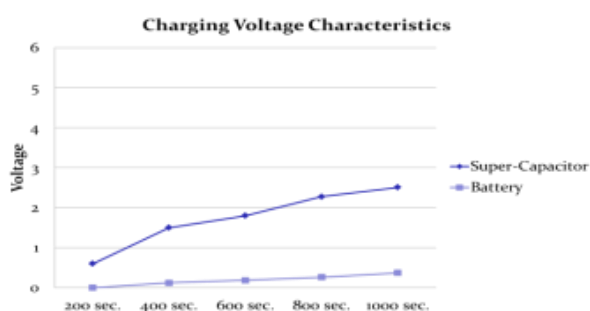


Fig 3: Charging Voltage Characteristics

### 3. Operation of motor using Supercapacitors and Battery:

A 6V DC motor is connected to the fully charged 5.4V supercapacitors and it is left to discharge. It is observed that it takes 10 hour 20 minutes to discharge fully. Similarly the motor is connected to battery and is left to discharge; it takes 10 hour 35 minutes to discharge fully. With this we can observe that the discharging characteristics of supercapacitor are comparable to battery.

#### Advantages of supercapacitors compared to battery:

1. While supercapacitors can't store as much energy as a comparably sized lithium-ion battery (they store roughly  $\frac{1}{4}$  the energy by weight), supercapacitors can compensate for that with the speed of charge, they're nearly 1,000 times faster than the charge time for a similar-capacity battery.

2. It offers high energy density and high power density compare to common capacitor. 3. It offers fast charging ability. 4. It offers longer Service and long life (about 10 to 15 years compare to 5-10 years of Li-ion battery). It offers virtually unlimited cycle life and can be cycled millions of time. 5. It offers higher reliability of

performance. 6. Supercapacitors meet environmental standards. Hence they are eco-friendly.

#### Disadvantages compared to battery:

1. They have higher self-discharge rate. This is considerably high compare to battery. 2. Individual cells have low voltages. Hence series connections are required in order to achieve higher voltages. 3. Amount of energy stored per unit weight is considerably lower compare to electrochemical battery. This is about 3 to 5 Wh/Kg for an supercapacitor than 30 to 40 Wh/Kg of a battery.

### III. CONCLUSION

This paper has proposed how supercapacitor as a power source has the potential to become a viable alternative to battery. The parameters presented in the observation data regarding charging and discharging of both battery and super-capacitor shows the advantages of super capacitor over battery as well as its limitations. It is shown that the charging time of supercapacitor is significantly shorter than battery when they are charged at same voltage. When motor is connected to observe the discharging characteristics both of the power sources showed similar results with respect to time taken to completely discharge.

By arranging the graphene layers in a manner that there is a gap between the individual layers, the researchers were able to establish a manufacturing method that efficiently uses the intrinsic surface area available of this nano-material. This prevents the individual graphene layers from restacking into graphite, which would reduce the storage surface and consequently the amount of energy storage capacity. To boost the storage capacity, Pope and his team developed a method to coat atomically thin layers of a conductor called graphene with an oily liquid salt in supercapacitor electrodes. The liquid salt serves as a spacer to separate the thin graphene sheets, preventing them from stacking like pieces of paper. The liquid salt dramatically helps in maximizing energy-storage capacity as well as minimizes the size and weight of the supercapacitor. Increasing the storage capacity of supercapacitors means they can be made small and light enough to replace batteries for more applications, particularly those requiring quick-charge, quick-discharge capabilities. Presently, nanotechnology is very expensive and developing it can cost you a lot of money. It is also pretty difficult to manufacture, which is

probably why products made with nanotechnology are more expensive.

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