Enhancing Battery Life Using Super Capacitor

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ABSTRACT

Battery based applications are generally used in our day to day life. Batteries can only be supplied for the finite period of time. Usually usage of batteries, will lead to the reduction in the life of the batteries. Super-Capacitor is a new technology which has several merits in energy storage capacity. Super capacitors are becoming increasingly favored alternatives for the conventional and traditional battery sources. Because of its flexibility, Super Capacitors can be reconciled where electrochemical batteries are used. Here the Super Capacitor is interfaced with that Battery based system to deliver maximum power output required for the load, so the life of the Battery will also be extended. The connection of Super Capacitors with Battery based applications are done for the various Battery ranges. The reduction in Battery stresses by using super capacitors are used as high power storage devices to smoothen the peak power applied to the Battery during backup time and to deliver full power during outage. MATLAB simulation has also been done for analysis and energy calculations of such system.

Keywords: - *Super capacitor, Power Supply, Relay, Battery, and Microcontroller PIC886.*

I. INTRODUCTION

This paper is worried with super capacitors (ultra capacitors) and its parallel reference to battery. Super capacitor is additionally referred to as electric double layer capacitor or electrochemical double layer capacitor because it stores charge in electric double layer of surface-electrolytic interface.[1,4] This interface is primarily a high area carbon. The massive area, not to mention the tight area of double layer, gives the device one in all the very best capacitance output of any capacitor around. . Super capacitor encompasses a high capacity with capacitance value much larger than normal capacitors, but with decreased voltage limits that unites the gap between rechargeable batteries and electrolytic capacitors. It acquires 10 to 100 times higher energy per unit mass than electrolytic capacitors. It accepts and delivers charge much faster than batteries, and tolerates more charge and discharge cycles. The range of super capacitor is of the order 1F to 2500F. [2,3]The concept behind ultra capacitors (super capacitors) has drawn lots of attention since conception because of the technology's especially high capacitance with an almost unlimited charge/discharge cycle life. Super capacitors assure an operational voltage between one to three V for both organic and aqueous electrolytes, with the potential for incredible energy storage and rapid charging. Most electronic companies currently make ECs, including Maxwell, Murata, and Tecate Group. By and huge, the technology is often used utilized in transportation and energy solutions.[1,2] Current applications comprise the automotive industry, hybrid transportation systems round the world, grid stabilization, utility vehicles, and rail-system power models.

Figure – 500F –3v super capacitor

A. SUPER CAPACITORS

As the name suggests, Super capacitor is a capacitor with large capacitance. It separates an electrolytic solution to accumulate energy electro-statically. Though an electrochemical device, no electrochemical reactions are sophisticated in its energy storage mechanism.[3,4] This mechanism is highly reversible, and allows the super capacitor to be charged and discharged hundreds of thousands of times, without any appreciable loss in its capacitance. Super capacitors (Ultra capacitor/Ultra caps/Electrochemical Double Layer Capacitors), with its short charging & discharging time, is ideally suited for the intermittent loads.[2]

Starting with the initiation of 'Coin/Button Cells' in the '80s to the present mega-super- capacitor units, the industry has come a long way. In the '80s and '90s, manufacturing of Super-capacitors was primarily an art. With the advancement in technology, automated assembly techniques have recovered the labor-intensive aspects of manufacturing. As a result, costs have decreased substantially.

A1. Characteristics of Super Capacitor

- Operating Voltage: Aqueous electrolytes – 1V; Organic electrolytes – 2 to 3V.
- Operating Temperature: -40°C to +85ºC
- Operating Life: 5000 to 50000 hrs
- Pulse Load: 0.1 to 100A
- Pollution Potential: No heavy metals
- Energy Density: 0.05 to 10Wh/kg
- Charge/Discharge time: Milliseconds to seconds
- Power Density: 0.01 to 10 kw/kg.

Figure 2- Charging curve

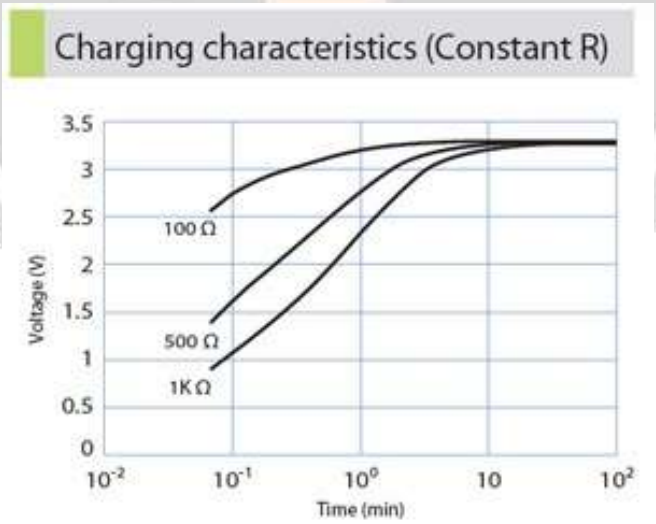
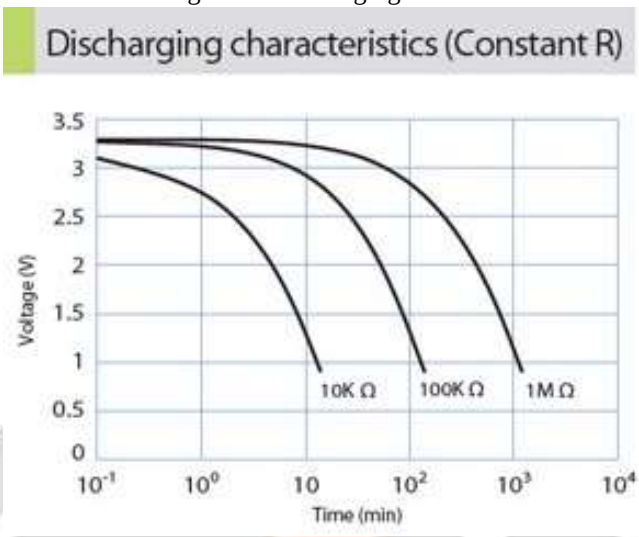


Figure 3- Discharging curve



A2. ***Super Capacitor Bank***

Consider there are number of super capacitors that are to be connected in series(C1,C2.....Cn).Each capacitor is having voltage 3v and capacitance 500F.We need total 12V in order to drive the load as our battery is also of 12 V. When super capacitors are connected in series the voltage gets added up.[3,4] There are positive and negative terminals on capacitors. In order to get this connections are done by connecting positive terminal of first capacitor to the negative of second capacitor and positive of third capacitor to negative of fourth capacitor and positive of fourth capacitor is taken as source. The output of the capacitor bank will be 3*4=12V.
The equivalent capacitance of capacitors is given as
1/Ceq=1/C1+1/C2+1/C3+1/C4.Hence the total capacitance becomes 125F.

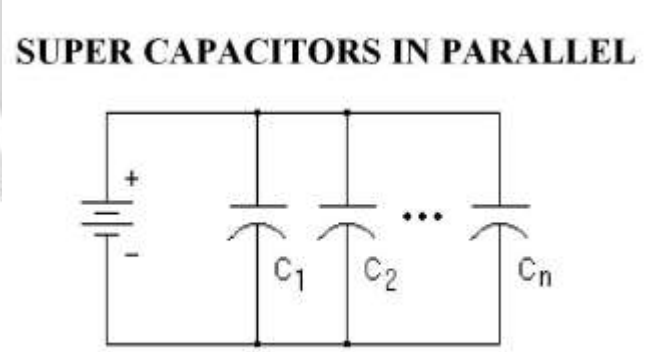


Figure 4- parallel connection

B. BATTERY

The battery used for this purpose is lead acid battery. Lead acid was the first rechargeable battery used for the commercial use. It still has no cost effective alternative in modern day cars or bikes. Despite containing toxic element like lead, though, one of the cheapest rechargeable battery and produce more power than other batteries available in the market.

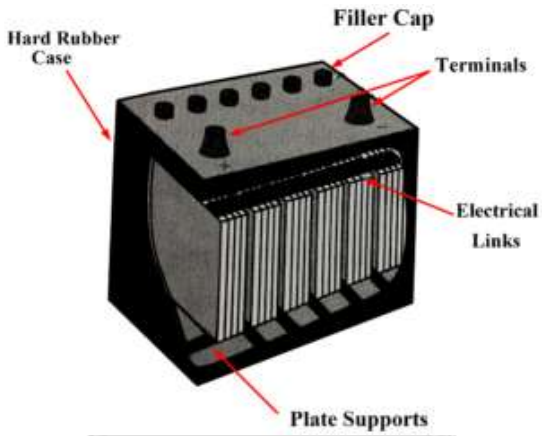


Figure 5- Lead- Acid Battery

B1. ***Parallel combination of battery and super capacitor***

The battery and the super capacitor are connected in parallel in order to drive the given load. There is relay (switch) acting between these two. Switch will be controlled by microcontroller. The battery has a voltage of 12 V and the super capacitor bank also has 12 V. Hence the load will be delivered simultaneously by battery and super capacitor. When capacitor is charged the

battery will be disconnected and the load will be delivered by super capacitor until it gets charged again. In this way the battery is being saved and its life is increased.

C. POWER SUPPLY

The importance of power supply in our project is to give continuous voltages to the various components like microcontroller, liquid crystal display, sensors, relays, drivers, etc. Power supplies are AC or DC types.

1. Regulated power supply are gives a constant voltages according to requirement of a circuit irrespective of any fluctuations.

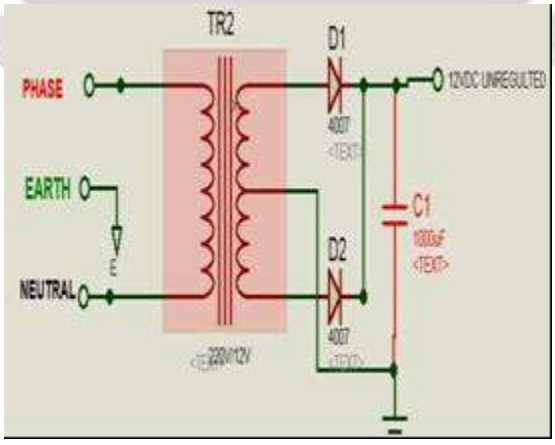


Figure 6- Regulated supply connection

In the project, some components required constant 5 volt like microcontroller, LCD, sensors and some requires 12 volts like relay and relay drivers.

2. Unregulated power supply are those which are not constant, means if we design power supply which converts 220 volt AC to 12 volt AC with the help of resistances, inductors, transformers in which the output 12 volt is directly proportional to the input 220 volt.

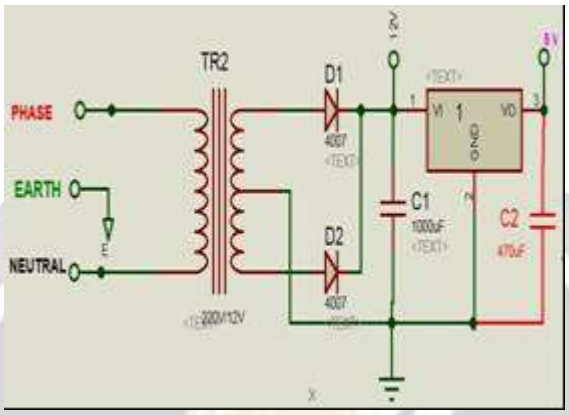


Figure 7- Unregulated supply connection

In power supply of the project, we used step down transformer of 220 volt AC to 12v AC. The reason behind selecting a 220 volt by 12v transformer is that, in case of mains voltage which falls up to 50% that is up-to 110v AC. In this case, transformer gives at least 6 volts AC.

Further the output of step down transformer is converted to DC with the help of full wave rectifier using diodes. The output of rectifier is pulsating DC which further filter by a filter capacitor.

The rectified DC output is unregulated which cannot be given directly to the circuit as microcontroller works on 5 volt dc only. To convert the unregulated rectified DC to constant 5 volts we use zener regulation circuit with the help of regulator IC 7805.

7805 regulator has a provision against short circuit and thermal shutdown. The maximum current Sourcing of 7805 IC is upto 1 ampere.

The capacitor C2 is used as a storage capacitor which stores 5vdc. The reason behind taking this capacitor is that there is only regulator IC 7805 which gives 5v to all the circuits, and if all the components requires a 5v at a time in that case output of regulator falls, which may results to resetting the microcontroller. Hence in case of loading to regulator, a capacitor C2 delivers the 5v stores inside it to the components and protects a microcontroller against a fractional reset.

D. MICRO-CONTROLLER (PIC 886)

Microcontroller 886 is employed to regulate all the relays, battery voltage, capacitor voltage, disconnecting super capacitor. It's used because it's several advantages over other micro controllers.

D1. *Precision Internal Oscillator*

- Factory calibrated to ±1%

- Software selectable frequency range of 10 MHz to 30kHz - Software tunable
- Two-Speed Start-up mode
- Crystal fail detect for critical applications
- Clock mode switching during operation for power savings.
- Power-Saving Sleep mode
- Wide operating voltage range (2-5V)
- Industrial and Extended Temperature range
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Brown-out Reset (BOR) amidst software control option
- Enhanced low-current Watchdog Timer (WDT) with on-chip oscillator (software selectable nominal 268 seconds with full pre scalar) amidst software enable
- Multiplexed Master Clear beside pull-up/input pin
- Programmable code protection
- High Endurance Flash/EEPROM cell: - 100,00 write Flash endurance - 1,000,00 write EEPROM endurance - Flash/Data EEPROM retention: > 30 years
- Program memory Read/Write during run time

E. RELAYS

Relay is an electrically operated switch which performs switching operations. Relay is controlled by microcontroller .Relays used in this circuit perform different functions:-

- To turn ON the circuit
- To turn OFF the circuit or disable it
- To change the polarity of the wire
- To increase the current supply of the wire.

There are four relays used in this circuit:

1. Charging relay - Charging relay is used to charge battery and super capacitor.
2. Source selection relay – This relay is particularly used to select a particular load. In this case the loads are super capacitor and battery.
3. Load relay – Load relay is used to connect/disconnect the load
4. Head lamp relay - Head lamp relay is used to on/off head lamp functions (upper / dipper).

II. WORKING

Firstly, the vehicle generator is present in the vehicle. This vehicle generator is connected to the charger. Charger is used to charge the battery or the super capacitor. Charger is connected to battery and capacitor charging relay. Through the capacitor charging relay the super capacitor is charged. Both battery and super capacitor are connected to microcontroller. Microcontroller controls and monitors the voltage values. Microcontroller needs 5V to operate. But the battery output is 12V ,hence a voltage regulator is used to lower down voltage to 5V .Initially the super capacitor will be uncharged. Once it gets charged there will be two sources present in circuit that is battery and super capacitor. Both these are connected to source selection relay where it will select super capacitor to drive the load until it gets discharged to a certain value. After that the load will be shifted to battery until it gets charged again. Load relay is used to drive the load. A relay driver is used to drive all the relays controlled by microcontroller.

If we drive our vehicle at night and if the vehicle coming from the opposite side has upper beam we get difficulty in visibility So, if this mechanism is installed in both the vehicles, with the help of LDR(light dependent resistor) when two vehicles will come across each other the upper beam will automatically shifted down to lower beam. Once the vehicles will cross each other the light will be shifted to upper beam again. Hence this acts as a safety feature.

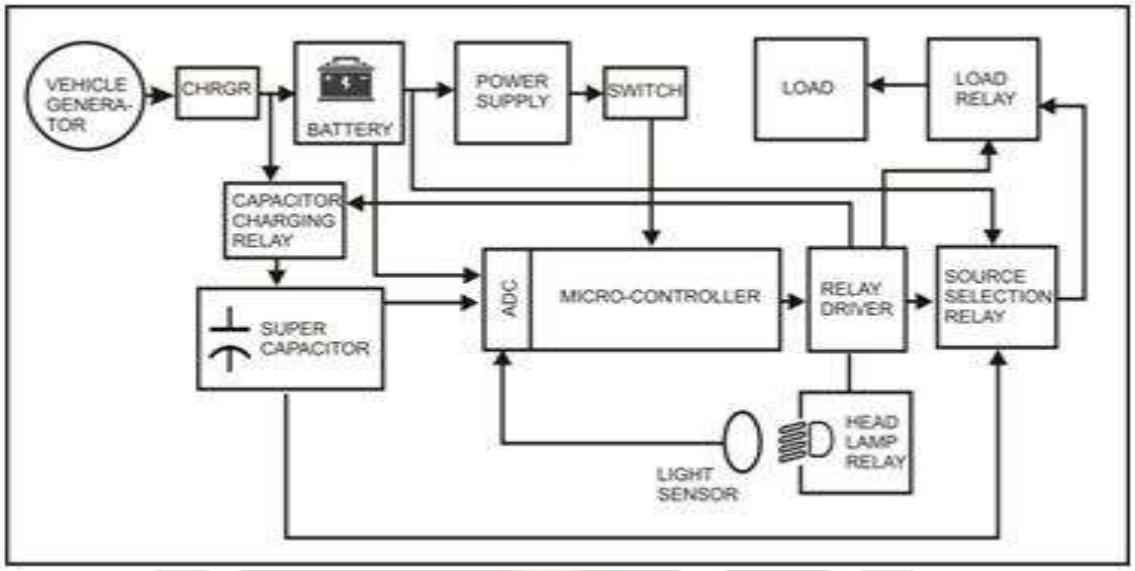


Figure 8- Block Diagram

III. SIMULATION STUDIES

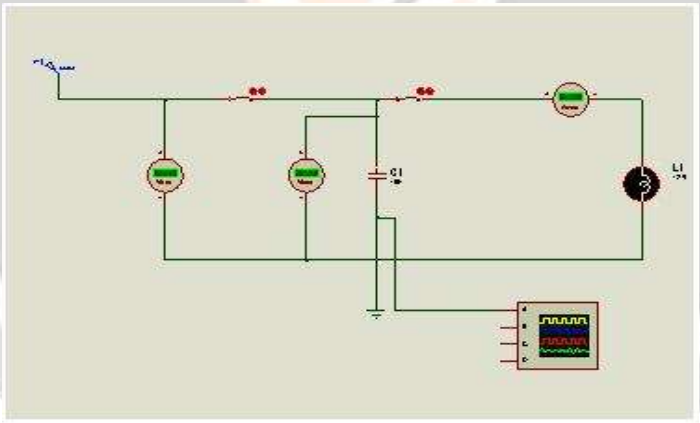


Figure 9- Simulation diagram on PROTEUS

Simulation model was built on PROTEUS SOFTWARE for demonstration of circuit model. A 12V source is used to charge the super capacitor .A voltmeter is used to measure voltage. A lamp is connected across super capacitor as load. The charging and discharging graph of super capacitor is shown. In this, with the help of oscilloscope, graph is seen that the super capacitor is charging fast and discharging according to the given load. Hence, the charging of the super capacitor in the vehicle will be fast and it will drive the load.

The charging and discharging of super capacitor is shown in the figure 9 above.

IV. RESULTS

1. The charging and discharging of super capacitor are studied.

2. The slope shows super capacitor charges very fast and discharges according to the load.
3. The super capacitor bank is charged to 12v and then discharge slowly.
4. The curve showing of charging and discharging of the super capacitor are displayed on the digital oscilloscope in figure 10 below.

Figure 10- Charging and discharging curve on digital oscilloscope.

V. CONCLUSION

1. The use of a battery-super capacitor connection proved to be beneficial for the run- time extension
2. This loss reduction effect is accompanied by an improvement in the power delivering capability.
3. Parallel reconnection leads to faster process during exchange of energy.
4. In future, the batteries may happen to totally be replaced by super capacitors.

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