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Integration of Battery and Super Capacitor for Energy Storage System

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Abstract: Battery based applications are often used in our day to day life. Batteries can only be supplied for the limited period of time. Often usage of batteries, will lead to the reduction in the life span of the batteries. Super-Capacitor is a new technology which has several advantages in energy storage capacity. Super capacitors are becoming increasingly popular alternatives for the conventional and traditional battery sources. Because of its flexibility, Super Capacitors can be adapted 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 interfacing of Super Capacitors with Battery based applications are done for the appropriate 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.

Keywords: Super capacitor; Battery source; Energy storage; High power storage.

I. INTRODUCTION

As communities and industries continue to expand, delivering power becomes more challenging. In India the use of electronic loads is increasing very fast and the gap between demand and the supply have made the reliability and power quality a critical issue.

II.BATTERY

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smart phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work.

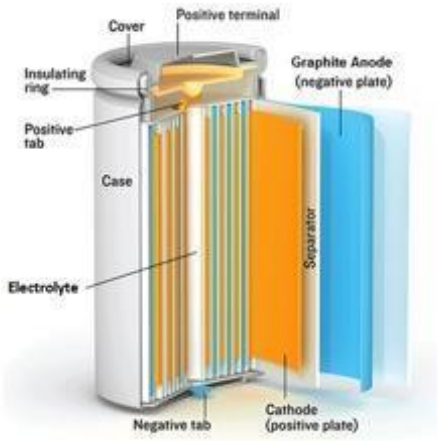

Fig 1. Structure of a battery

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A battery's capacity is the amount of electric charge it can deliver at the rated voltage. The more electrode material contained in the cell the greater its capacity. A small cell has less capacity than a larger cell with the same chemistry, although they develop the same open-circuit voltage. Capacity is measured in units such as amp-hour (A-h). The rated capacity of a battery is usually expressed as the product of 20 hours multiplied by the current that a new battery can consistently supply for 20 hours at 68 °F (20 °C), while remaining above a specified terminal voltage per cell. For example, a battery rated at 100 A-h can deliver 5 A over a 20-hour period at room temperature. The fraction of the stored charge that a battery can deliver depends on multiple factors, including battery chemistry, the rate at which the charge is delivered (current), the required terminal voltage, the storage period, ambient temperature and other factors.

Battery life can be extended by storing the batteries at a low temperature, as in a refrigerator or freezer, which slows the side reactions. Such storage can extend the life of alkaline batteries by about 5%; rechargeable batteries can hold their charge much longer, depending upon type. To reach their maximum voltage, batteries must be returned to room temperature; discharging an alkaline battery at 250 mA at 0 °C is only half as efficient as at 20 °C.

III. SUPER CAPACITOR

A super capacitor (SC) (also electric double layer capacitor (EDLC), also called super cap, ultra capacitor or Gold cap) is a high- capacity capacitor with capacitance values much higher than other capacitors (but lower voltage limits) that bridge the gap between electrolytic capacitors and rechargeable batteries. They typically store 10 to 100 times more energy per unit volume or mass than electrolytic capacitors, can accept and deliver charge much faster than batteries, and tolerate many more charge and discharge cycles than rechargeable batteries.

Fig 2. Super capacitor

Super capacitors are used in applications requiring many rapid charge/discharge cycles rather than long term compact energy storage: within cars, buses, trains, cranes and elevators, where they are used for regenerative braking, short-term energy storage or burst-mode power delivery. Operating super capacitors below the rated voltage improves the long-time behaviour of the electrical parameters. Capacitance values and internal resistance during cycling are more stable and lifetime and charge/discharge cycles may be extended. Super capacitors occupy the gap between high power/low energy electrolytic capacitors and low power/high energy rechargeable batteries.

There are four application classes, according to discharge current levels:

1. Memory backup.
2. Energy storage, mainly used for driving motors requires a short time operation.
3. Power, higher power demand for a long time operation.
4. Instantaneous power, for applications that requires relatively high current units or peak currents ranging up to several hundreds of amperes even with a short operating time.

IV.ARDUINO

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world.

In this project we used it to sense and control the relay circuit.

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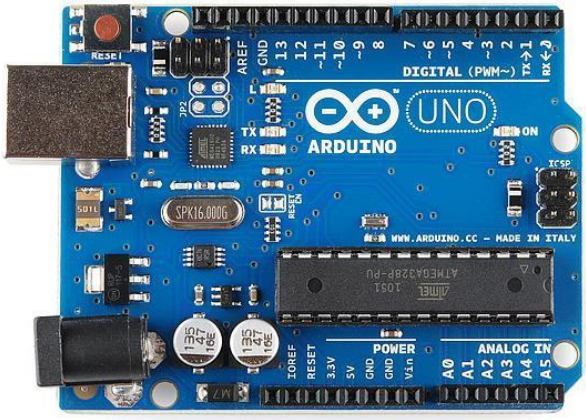

Fig 3. Arduino UNO

V.INTERFACING

By interfacing a super capacitor with a battery-based system, the life of the batteries can be extended. The batteries provide power only during the longer interruptions, reducing the cycling duty on the battery. Small super capacitors are commercially available to extend battery life in electronic equipments, but large super capacitors are still in development, but may soon become a viable component of the energy storage field. The most significant advantage super capacitors have over batteries is their ability to be charged and discharges continuously without degrading like batteries do. They can be made in any size, and their light weight and low cost make them attractive for most portable electronics and phones, as well as aircraft and automobiles.
Projected Scheme

VI.DESCRIPTION OF BLOCK DIAGRAM

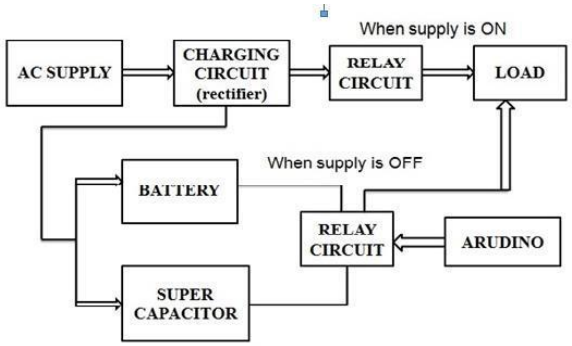

Fig.4. Block Diagram

The circuit is similar to the uninterrupted power supplies system. Supply is given to the load, battery as well as the super capacitor. The relay circuit is used to switch the connection between battery and super capacitor.

When the supply is ON:
When the supply is in “ON condition” the load directly utilizes the power from the source.

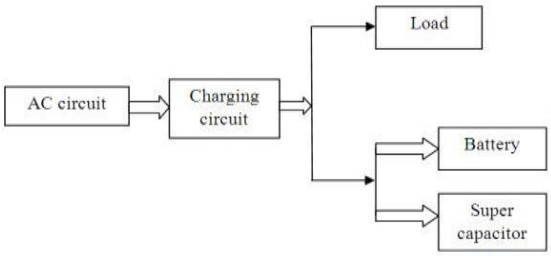

Fig.5. Diagram when supply is in ON condition

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It is also used to charge the battery and super capacitor which is connected in parallel. When both reaches the full charge it is automatically cut off from the supply.

When the supply is OFF:
The supply cut off is sensed using a relay circuit, which switches the connection to the battery and super capacitor. The first backup to the load is taken from the super capacitor, if it drains then it takes from the super capacitor.
Relay circuit monitors the super capacitor value continuously if it reaches the specified value it switches the connection to the battery hence the load utilizes it.

VII.EXPERIMENTAL SETUP

The experimental setup of the proposed model is as shown in figure below.

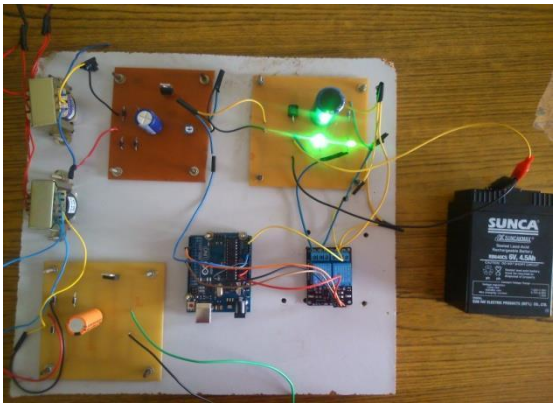

Fig.6. Experimental Setup

VIII.ARDUINO PROGRAM

The Arduino program has been written for the relay controlling circuit. The arduino program will control the relay circuit which in turn controls the entire circuit to switch the power to load.

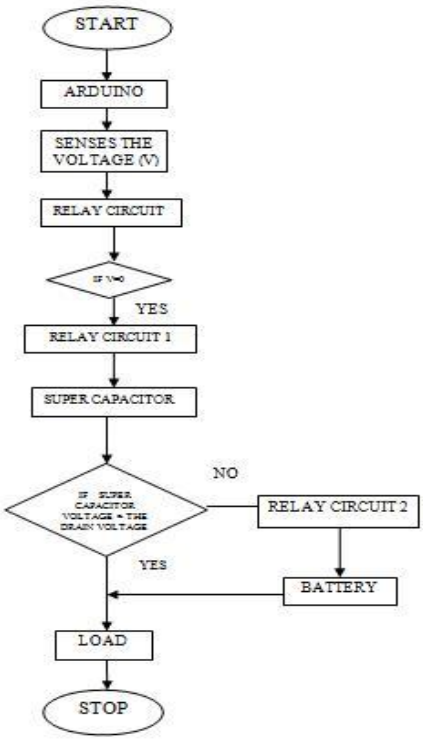

Fig 7. Flow chart

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IX. RESULTS AND OUTCOMES

This graph depicts voltage vs.time of a battery

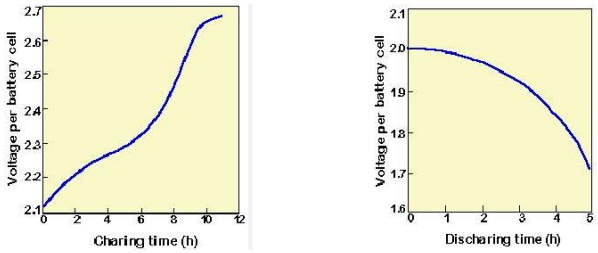

Fig 8.Charging and discharging of a battery

This graph depicts voltage vs time of a super capacitor.

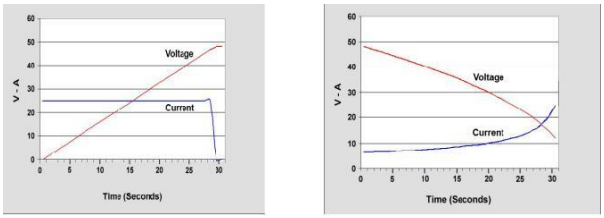

Fig 9. Charging and discharging time of a super capacitor

X.CONCLUSION

Several energy storage device are available today, among these energy storage devices super capacitors show some important advantages due to their high power density, reduced size and weight. The parallel connection of battery and super capacitor was proposed and evaluated. The use of a battery-super capacitor connection proved to be beneficial for run-time extension, which is achieved due to the reduction in the battery losses. This loss reduction effect is accompanied by an improvement in the power delivering capability. In future the batteries will totally be replaced by super capacitors. It can also be used in Laptop, emergency light, car batteries, UPS and mobiles.

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