SUPER-CAPACITOR BASED UPS

Mrs. Shalini Kumari[1,] and Mrs. Neha Shrivastava[2]*

[1] Assistant Professor, Department Of Electronics & Communication Engineering
RVS College of Engineering and Technology Jamshedpur, India.
E-mail: shalini_kumari@hotmail.com

[2]Assistant Professor, Department of Electronics and Communication Engineering,
E-mail: nehamit0505@gmail.com

Abstract—SUPER-CAPACITOR is a new technology which has advances in energy storage capacity. Super-capacitors are almost having same characteristic as conventional capacitor, but utilize higher surface area electrodes and thinner dielectric to achieve higher capacitances. Its energy density is much higher than those of conventional capacitor and power density greater than those of batteries. All these make it an attractive power solution for future applications.

Keywords—- Super-capacitor, battery, UPS etc.

I. INTRODUCTION

This project represents a study of the reduction in battery stresses by using SUPERCAPACITOR in UPS. The super-capacitors are used as high power storage devices to smooth the peak power applied to the battery during backup time and to deliver full power during short grid outage.

In many industrial sectors, high reliability power supply is required for critical loads. Uninterruptible power supplies (UPS) are used to improve power quality and guarantee the reliability of backup power. There are many disadvantages associated with batteries such as low-power density and limited charge/discharge cycles. A super-capacitor is a double- layer electrochemical capacitor that can store thousand times more energy than a typical capacitor. It shares the characteristics of both batteries and conventional capacitors and has an energy density about 20% of a battery.

Combining super capacitors with battery-based UPS system gives the best of high energy and high-power configurations. By replacing the battery of UPS with super-capacitor we can decrease the charging time and increase the efficiency of UPS.

II. SUPER CAPACITOR

2.1 Definition- Super-capacitor, also known as electric double-layer capacitor or ultra-capacitor is the generic term for a family of electrochemical capacitors (ECs). Super-capacitors bridge the gap between conventional capacitors and rechargeable batteries. They store the most energy per unit volume or mass among capacitors. The capacitance value of an electrochemical capacitor is determined by two storage principles:

- Double layer capacitance - Electrostatic storage achieved by separation of charge in a double layer at the interface between the surface of a conductive electrode and an electrolyte.
- Pseudo-capacitance - Faradaic electrochemical storage with electron charge- transfer, achieved by redox reactions, intercalation or electro sorption.

2.2 History-Super-capacitor stores electrical charge in electric double layer at a surface-electrolyte interface, primarily in high-surface-area carbon. Because of the high surface area and the thinness of the double layer, these devices can have a very high specific and volumetric capacitance. This enables them to combine a previously unattainable capacitance density with an essentially unlimited charge/discharge cycle life.

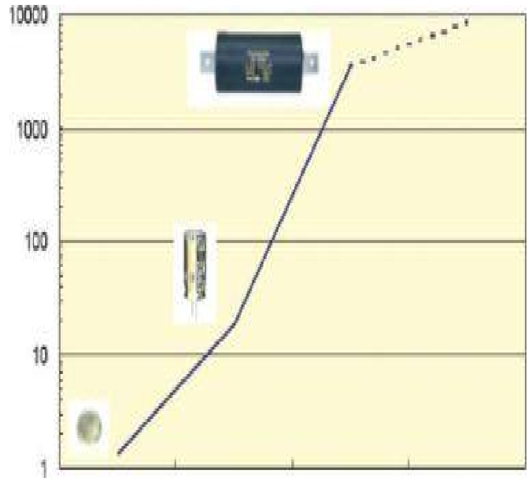
The concept of storing electrical energy in the electric double layer that is formed at the interface between an electrolyte and a solid has been known since 1800s. The first electrical device using double-layer charge storage was reported in 1957 by H.I. Becker of General Electric. Becker's device was impractical in that, similarly to a flooded battery, both electrodes needed to be immersed in a container of electrolyte, and the device was never commercialized.

Becker did appreciate the large capacitance values subsequently achieved by Mr. Robert A. Right mire, a chemist at the Standard Oil Company of Ohio (SOHIO), to whom can be attributed the invention of the device in the format now commonly used.
In 1962, carbon double-layer capacitors originated with practical devices developed by SOHIO. Work began in the early 1960s as an outgrowth of fuel cell-related development activity. A fairly complete account of this early work as presented by Don Boos, one of the chemists involved in the project. In 1975, NEC began its fundamental investigations after licensing the technology from SOHIO. NEC began pre-production of the FA series in 1978. These were sampled for many different potential applications.

.

In December 1993 Dr. Alexander Ivanov presented a paper at Third International Seminar on Double Layer Capacitors that is Super-capacitors. Dr. Ivanov's company, ECOND, was located in Moscow. He described large capacitors being used to start 3,000 horsepower diesel locomotive engines. These capacitors not only stored a large amount of energy, but they were also some of the most powerful reported up to that time.

In 1973, Panasonic began manufacturing its ‘Gold cap’ double-layer capacitors in Japan. These were initially developed primarily to replace the reliable coin cell batteries used in memory back-up applications at that time. The major difference between the Panasonic and NEC products were the electrolyte and the fact that NEC used an aqueous electrolyte in a ‘pasted electrode’ with bipolar cell construction, while Panasonic used a non-aqueous electrolyte in a non-pasted electrode in the cell construction which offered higher unit cell operating voltage.



Graph 2.1: The performance improvements in Panasonic Goldcap capacitors

In early 1993 Alexey Beliakov, Technical Director of MP Pulsar in Kursk, Russia, sent a reader's letter to Batteries International. He presented pictures of very large capacitors, 30 and 50 kJ, 12 and 24 volts, used for engine starting. He described the testing done on these devices and talked about delivery of a 600kJ set of capacitors. MP Pulsar changed its name to ELIT. Development of the ELIT capacitor began in 1988 at Accumulator Plant in Kursk.

In 1989 ELNA, in collaboration with Asahi Glass of Japan, developed and began selling several styles of their organic electrolyte Dynacap EC in the U.S. ELNA produces coin cells and spiral wound products, some with the same package size and ratings as Panasonics Goldcap. They do make several families of capacitor cells quite different from Panasonic's sizes up to 200F and rated at 2.5 volts.

In 1991 Maxwell Technologies of San Diego, California developed a broad line of high- voltage capacitor products used in many of the early magnetic fusion machines and other high-energy-density applications of the time, like laser flash-lamp power supplies.
In December 1997 Dr. Arkadiy Klementov delivered a presentation titled 'Application of Ultra-capacitors as Traction Energy Sources' at Seventh International Seminar on Double Layer Capacitor and Similar Energy Storage Devices. He showed photographs of buses and trucks powered solely by ECs: no batteries, no gas engines

Fig 2.2: A Maxwell Boostcap

In 1998, NessCap rapidly developed capacitor manufacturing capability and a broad product line of ECs. NessCap products use an organic electrolyte with spiral wound prismatic cell construction which was first launched in market in mid 2000.

Fig 2.3: Nesscap capacitor module rated at 5000 Farads

2.3 Types of Super Capacitor-Super-capacitors are divided into three families, based on electrode design:

- Double-layer capacitor - Capacitors with carbon electrodes or derivates with much higher electrostatic double-layer capacitance than electrochemical pseudo capacitance.

- Pseudo-capacitors - Capacitors with metal oxide or conducting polymer electrodes with a high amount of electrochemical pseudo-capacitance.

• Hybrid capacitors - Capacitors with asymmetric electrodes, one of which exhibits mostly electrostatic and the other mostly electrochemical capacitance.

Super capacitors

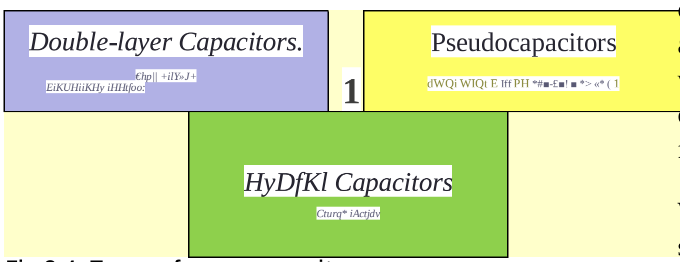


Fig 2.4: Types of super-capacitor

III. BLOCK DIAGRAM

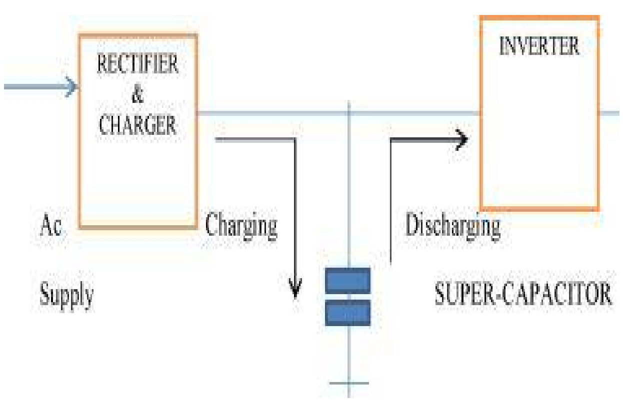


Fig 3.1: Charging and discharging

In many industrial sectors, high reliability power supply is required for critical load. Uninterruptible power supplies (UPS) are used to improve power qualities and guarantee the reliability of backup power. UPS basically relying on the choice of good lead-acid batteries.

However, there are many disadvantages associated with batteries such as low power density and limited charge/discharge cycles. Moreover, extracting pulsed power instead of average power from the battery can decrease its lifespan

To replace the battery by super-capacitor from the UPS circuit, the super-capacitor gives the best of high energy and high-power configuration. The super-capacitor ensures the power impulses and reduces high power demands.

3.1 Working Principle-The UPS block diagram consists of main supply, rectifier and charger, super-capacitor, inverter and load. When main supply is applied, rectifier converts ac voltage into dc voltage, which supplies power to inverter as well as the super-capacitor to charge it. The inverter gets a dc input from the rectifier when mains are ON.

When mains are OFF super-capacitor gives the power supply to inverter. Inverter converts dc into ac and gives supply to the critical load. When mains are apply supercapacitor start charging. A static switch will connect or disconnect the super-capacitor from the input of the invertor depending on the status of ac mains.

UPS are mainly three types

1- On-line or inverter UPS system

2- Off-line or line-preferred UPS system

3- Line-interactive UPS system

We used On-line or inverter UPS system in our project. On this mode of operation, the load is always connected to the inverter through the UPS static switch. The UPS static switch is normally 'ON' switch. It turns OFF only when the UPS system fails.

In that case the 'Main Static OFF' switch and used only when UPS is to be bypassed.

This type of system is more popular because it can provide full isolation of the critical load from the a.c line and also provide power conditioning. Also, the mode of operation does not change during the failure of power. Its changeover time is very less and there is no interruption during transfer from line to battery and vice versa.

This system protects the critical load against surges, spikes, line noise, frequency and voltage variation, brownout and outages. All this protections are not available in OFF-line UPS system.

IV. CALCULATION

4.1 Charging

We know that Energy for conventional capacitor

is $E = 1/2*C*V^2$ Where, E=energy

C= capacitance

V= voltage

The characteristics equation of super-capacitor is same as the conventional capacitor, so the energy for super-capacitor is

E = 1/2*C*V2

The value of capacitance of super-capacitor is 3000 F and voltage is 6V.

Therefore,

E = 1/2*3000*62 E = 54000 J

Now, for the charging time of super-capacitor

is E = Voltage*current*Time For this value of

Voltage= 6 V

Current= 10A

and Energy =54000 J Then charging time is,

5400 J= 6 V* 10 A* Time

Time=900 sec Time= 15 minutes The super-capacitor will charge into 15 minutes.

4.2 Discharging

Now discharging time of super-capacitor when critical load is an array of 10 LED's

The array of LED is made by connecting 2 LED in series and 5 in parallel. The LED has cut-off voltage 2.5 and current 20 mA.

So, we know that

E = V*I*T

Where, E = energy = 54000J

V = voltage = 6volt

I= current = 20mA

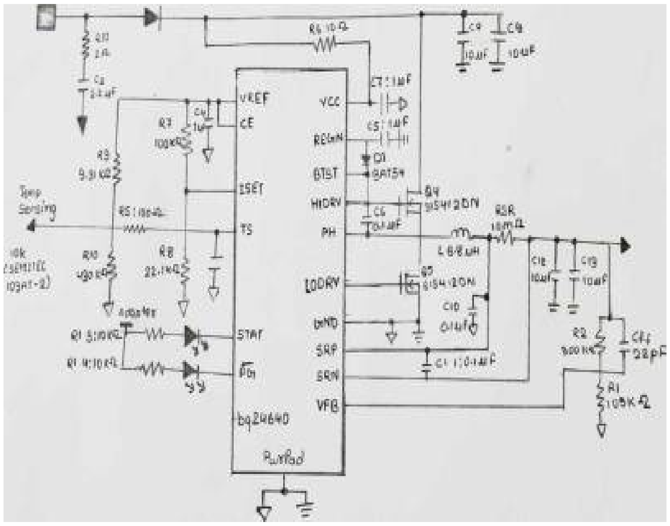
T = time

Or, 54000 = 6*5*20*10“3*T

T = 54000/6*5*20*10“3 T = 90,000 seconds T= 1,500 minutes T= 25 hours

The discharging time of super-capacitor is 25 hours. Thus, here theoretically we find charging time of super-capacitor is 15 minutes and discharging time is 25 hours

V. CIRCUIT DIAGRAM



5.1 Charging Circuit-

Fig 5.1: Charging circuit

5.1.1 Features

- •Charge Super Capacitor Pack from 2.1V to 26 V
- •Over 90% Efficiency for up to 10A Charge Current
- •5V-28V VCC Input Voltage Range
- •Accuracy +-0.5% charge voltage regulation +- 3% charge current regulation
- •Safety
- Input over voltage protection
- Capacitor temperature sensing hot/cold charge sensed
- Thermal shutdown

The bq24640 is highly integrated switch-mode super-capacitor charge controller. It offers a constant frequency synchronous PWM controller with high accuracy charge current and voltage regulation, and charge status monitoring.

The bq24640 charges super-capacitor in two phases: constant current and constant voltage. The bq24640 has an input CE pin to enable and disable charge; and, the STAT and PG output pins report charge and adapter status. The TS pin on the bq24640 monitors the temperature of the capacitor and suspends charge during HOT/COLD conditions.

5.1.2 Pin Diagram*******************

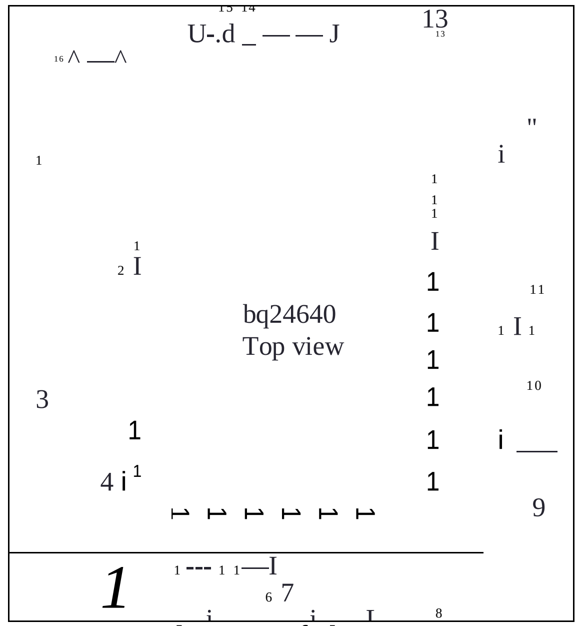


Fig 5.2: Pin diagram of charging circuit

5.1.3 Pin Function

1. VCC - IC power +ve supply. Connect through a 10 ohm resistor to the cathode of input diode.

2. CE - Charge enable, active high logic i/p. Connect to pull-up rail with 10 kilo ohm resistor.

3. STAT - Open drain charge status o/p to indicate various charger operations. Connect to the pull up rail through the LED and 10 ohm.

4. TS - Temp. qualification voltage i/p for -ve temp. co-efficient thermistor.

5. PG - Open drain active low adapter status output. Connect to pull up rail through LED turns on when a valid is detected, off in the sleep mode.

6. VREF - 3.3V reference voltage output. Place a 1pF ceramic capacitor from VREF to GND pin close to the IC.

7. ISET - Charge current set point. The voltage is set through a voltage divider from VREF to ISET & to GND.

8. VFB - Charge voltage analog feedback adjustment. Connect a resistor divider from o/p to VFB to GND to adjust the o/p voltage.

9. SRN - Charge current sense resistor -ve i/p.

10. SRP - Charge current sense resistor, +ve i/p.

11. GND - Low current sensitive analog/digital ground.

12. REGN - PWM low side driver +ve 6V supply o/p. Connect a 1pF ceramic capacitor from REGN to GND pin close to the IC.

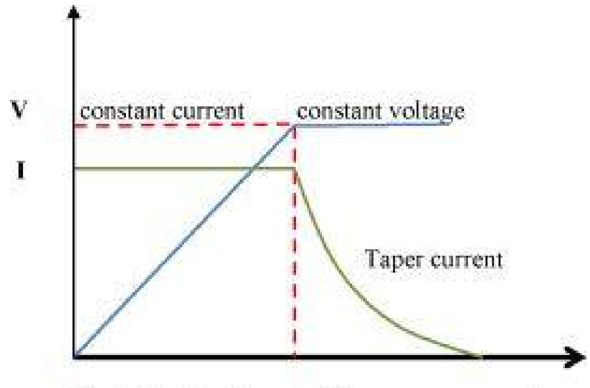
13. LODRV - PWM low side drive o/p. Connect to the gate of the low side N-channel power MOSFET with a short trace.

14. PH - Switching node, charge current o/p inductor connection. Connect the 0.1pF bootstrap capacitor from PH to BTST.

15. HIDRV - PWM high side driver o/p. Connect to the gate of the high side N-channel power MOSFET with a short trace.

16. BTST - PWM high side driver +ve supply. Connection the 0.1pF bootstrap capacitor from PH to BTST.

Exposed pad beneath the IC. Always solder power pad to the board, and have vias on the power pad plane star connecting to GND and ground plane for high current power converter.



Graph 5.1: V-I characteristics

OUTPUT VOLTAGE REGULATION:

The bq24640 uses a high accuracy voltage regulator for the charging voltage. The charge voltage is programmed via a resistor divider from the output to ground, with the midpoint tied to the VFB pin. The voltage at the VFB pin is regulated to 2.1V, giving the following equation for the regulation voltage:

$V_{out} = 2.1V\ [1+(R2/R1)]$

Where, R2 is connected from VFB to the output and R1 is connected from VFB to GND.

ENABLE AND DISABLE CHARGING:

The following conditions have to be valid before charge is enabled:

- CE is HIGH
- The device is not in Under-Voltage-Lockout (UVLO) mode, and not in VCCLOWV
- 30ms delay is complete after initial power-up
- The REGN LDO and VREF LDO voltages are at the correct levels
- Thermal Shut (TSHUT) is not valid
- TS fault is not detected
- One of the following conditions will stop on-going charging:
- CE is LOW;
- Adapter is removed, causing the device to enter VCCLOWV;
- The device is in SLEEP mode

- Adapter is over voltage;
- The REGN or VREF LDOs voltage are not valid;
- TSHUT IC temperature threshold is reached;
- TS voltage goes out of range indicating the temperature is too hot or too Cold.

THERMAL SHUTDOWN PROTECTION:

The QFN package has low thermal impedance, which provides good thermal conduction from the silicon to the ambient, to keep junctions temperatures low. As added level of protection, the charger converter turns off and self-protects whenever the junction temperature exceeds the TSHUT threshold of 145°C. The charger stays off until the junction temperature falls below 130°C.

TYPICAL INDUCTOR, CAPACITOR, AND SENSE RESISTOR VALUES AS A FUNCTION OF CHARGE CURRENT:-

Charge Current -	**2A**	**4A**	**6A**	**8A**	**10A**
Output Inductor Lo -	10 pH	6.8 pH	4.7 pH	3.3pH	3.3pH
Output Capacitor Co -	15 pF	20 pF	30 pF	40 pF	40pF
Sense Resistor -	10mQ	10mQ	10mQ	10mQ	10mQ

5.2 DISCHARGING CIRCUIT

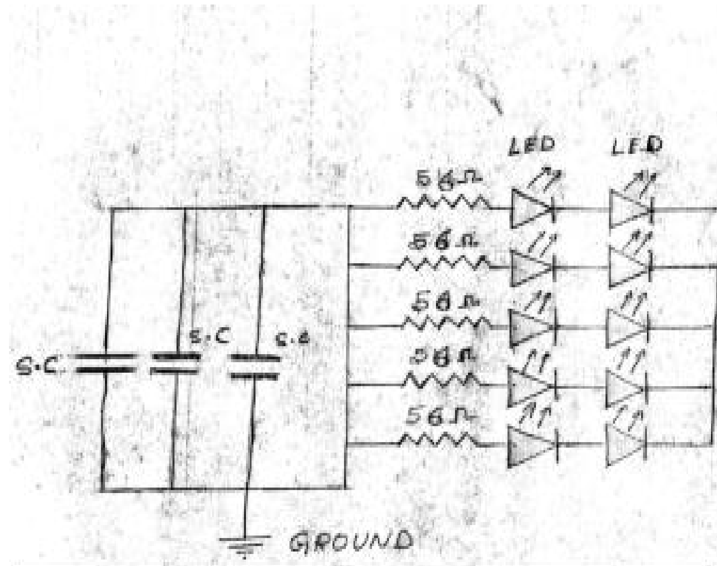


Fig 5.3: Discharging circuit

5.2.1 Description

To make LED array we use LED (20 mm) and resistor of 56Q.

LED:- LED stands for light emitting diode; it is simple P-N junction diode. It operates when it's properly forward biased and capable of emitting external spontaneous radiation in the visible range of nearby infrared region of the electromagnetic spectrum matching and the material properties, it emits various color of light.

Here we used 20 mm white LED which has cut-off voltage 2.5 volt and current 20mA. We used total 10 LED and arrangement is shown in fig.

Resistor:- Resistor can be defining as the resistance of current flowing path. According to OHM's law,

Voltage=Current*Resistance

Here we use 56Q in series with LED, to control the flow of current.

VI. APPLICATIONS

Applications

- HYBRID ELECTRIC VEHICLES: - Super-capacitor combination in electric vehicles and hybrid electric vehicles are well are well investigated. A 20 to 60% fuel reduction has been claimed by recovering brake energy in EVs or HEVs. The ability of super-capacitors to charge much faster than batteries, their stable electrical properties, broader temperature range and longer lifetime are suitable, but weight, volume and especially cost mitigate those advantages.

Fig 6.1: Hybrid Car

• MOTOR RACING:- The Toyoto TS030 Hybrid Toyota TS030 LMP1 car, a racing car_developed under uses a hybrid drivetrain with super-capacitors. In the 2012 24 Hours of Le Mans race a TS030 qualified with a fastest lap only 1.055 seconds slower than the fastest car, an Audi R18 e-tron guattro with flywheel energy storage. The super-capacitor and flywheel components, whose rapid charge-discharge capabilities help in both braking and acceleration, made the Audi and Toyota hybrids the fastest cars in the race. In the 2012 Le Mans race the two competing TS030s, one of which was in the lead for part of the race, both retired for reasons unrelated to the super-capacitors. The TS030 won three of the 8 races in the 2012 FIA World Endurance Championship season In 2014 the Toyota TS040 Hybrid used a super-capacitor to add 480 horsepower from two electric motors.

Fig6.2: Toyota TS040 Hybrid

- BUSES:- The first hybrid bus with super-capacitors in Europe came in 2001 in Nuremberg, Germany. It was MAN's so-called "Ultracapbus", and was tested in real operation in 2001/2002. The test vehicle was equipped with a diesel-electric drive in combination with super-capacitors. The system was supplied with 8 Ultracap modules of 80 V, each containing 36 components. The system worked with 640 V and could be charged/discharged at 400 A. Its energy content was 0.4 kWh with a weight of 400 kg.The super-capacitors recaptured braking energy and delivered starting energy. Fuel consumption was reduced by 10 to 15% compared to conventional diesel vehicles. Other advantages included reduction of CO_2 emissions, quiet and emissions-free engine starts, lower vibration and reduced maintenance costs.

In early 2005 Shanghai tested a new form of electric bus called Capabus that runs without power lines (catenary free operation) using large onboard super-capacitors that partially recharge whenever the bus is at a stop (under so-called electric umbrellas), and fully charge in the terminus. In 2006, two commercial bus routes began to use the capabuses; one of them is route 11 in Shanghai. It was estimated that the super-capacitor bus was cheaper than a lithium-ion battery bus, and one of its buses had one-tenth the energy cost of a diesel bus with lifetime fuel savings of $200,000.

Fig6.3: Electric Bus(capabus)

- LIGHT- RAILS AND TRAMS:- In 2003 Mannheim adopted a prototype light - rails _vehicle (LRV) using the MITRAC Energy Saver system from Bombardier Transportation to store mechanical braking energy with a roof-mounted super capacitor unit. It contains several units each made of 192 capacitors with 2700 F /2.7 V interconnected in three parallel lines. This circuit results in a 518 V system with energy content of 1.5 kWh.

Fig6.4: Light -rails in Mennheim

In August 2012 the CSR Zhouzhou Electric Locomotive corporation of China presented a prototype two-car light metro train equipped with a roof-mounted super-capacitor unit. The train can travel up 2 km without wires, recharging in 30 seconds at stations via a ground mounted pickup. The supplier claimed the trains could be used in 100 small and medium-sized Chinese cities.

Fig6.5: Light-rails in Hong-kong

- CRANES FROKLIFTS AND TRACTORS:- Mobile hybrid diesel-electric rubber tired gantry cranes move and stack containers within a terminal. Lifting the boxes requires large amounts of energy. Some of the energy could be recaptured while lowering the load resulting in improved efficiency.

A triple hybrid forklift truck uses fuel cells and batteries as primary energy storage and super-capacitors to buffer power peaks by storing braking energy. They provide the fork lift with peak power over 30 kW. The triple-hybrid system offers over 50% energy savings compared with diesel or fuel-cell systems. Super-capacitor-powered terminal tractors transport containers to warehouses. They provide an economical, quiet and pollution-free alternative to diesel terminal tractors.

Fig6.6: Containers Yard with rubber tyre

- RAILWAYS:- Super-capacitors can be used to supplement batteries in starter systems in diesel railroad locomotives with diesel-electric transmission. The capacitors capture the braking energy of a full stop and deliver the peak current for starting the diesel engine and acceleration of the train and ensure the stabilization of catenary voltage. Depending on the driving mode up to 30% energy saving is possible by recovery of braking energy. Low maintenance and environmentally friendly materials encouraged the choice of super-capacitors.

Fig6.7: Train locomotive

MILITARY:- Super-capacitors' low internal resistance supports applicationsthat require short-term high currents. Among the earliest uses were motor startup (cold diesel engine start) for large engines in tanks and submarines .Super-capacitors buffer the battery, handling short current peaks and reducing cycling. Further military applications that require high power density are phased array radar antennae, laser power supplies, military radio communications, avionics displays and instrumentation, backup power for airbag deployment and GPS- guided missiles and projectiles.

Fig6.8: Military Transports

- MEDICAL:- Super-capacitors are used in defibrillators which just like a pumping machine where they can deliver 500 joules to shock the heart back into sinus rhythm.

Fig6.9: Operation Department

- BUFFER POWER:- Super-capacitors provide backup or emergency shutdown power to low-power equipment such as RAM, SRAM, micro-controllers and PC Cards. They are the sole power source for low energy applications such as automated meter reading equipment or for event notification in industrial electronics .Super-capacitors buffer power to and from rechargeable batteries, mitigating the effects of short power interruptions and high current peaks. Batteries kick in only during extended interruptions, e.g., if the mains power or a fuel cell fails, which lengthens battery life ,where super-capacitors have replaced much larger banks of electrolytic capacitors. This combination reduces the cost per cycle, saves on replacement and maintenance costs, enables the battery to be downsized and extends battery life.

Fig6.10: Wind Trubine

- Super-capacitors provide backup power for actuators in wind turbine pitch systems, so that blade pitch can be adjusted even if the main supply fails.STREET LIGHT:- Street light combining a solar cell power source with LED lamps and super-capacitors for energy storage.Sado City, in Japan's has street lights that combine a stand-alone power source with solar cells and LEDs. Super-capacitors store the solar energy and supply 2 LED lamps, providing 15 W power consumption over night. The super- capacitors can last more than 10 years and offer stable performance under various weather conditions, including temperatures from +40 to below -20 °C.

Fig6.11: Street Light

- AERIAL LIFT:- In Austria, an aerial lift connects the city with Schmittenhohe mountain. It sometimes run 24 hours per day, using electricity for lights, door opening and communication. The only available time for recharging batteries at the stations is during the brief intervals of guest loading and unloading, which is too short to recharge batteries. Super-capacitors offer a fast charge, higher number of cycles and longer life time than batteries. The cabins are equipped with a modern infotainment system, which is powered by super-capacitors.

Fig6.12: Aerial Lift

- TOY :- Toy applications, where the total running time is typically not longer than 10 hours . A super-capacitor designed for ten years or several 100'000 cycles is not optimized for such application, lower performance is thoroughly sufficient. For short terms the largest markets are for devices with <12 V and only around 2004 the market for devices with > 48 V will have grown to the same size and will give opportunities for the super-capacitor market.

Fig6.13: Electronic Toy

- GSM - During the short 0.5 ms pulse of 1 A, the battery voltage drops considerably. If it is below a certain limit, the phone is no longer operable. With a super-capacitor the voltage drop is reduced significantly and it takes much longer until the critical low voltage is reached during the pulse. In essence the operation time of the phone is extended.

Fig6.14: GSM Application

VII. ADVANTAGES AND DISADVANTAGES

7.1 Advantages

- Super-capacitors have high energy capability.
- Super-capacitors have less charging cycle than that of batteries.
- Super-capacitors are more efficient than batteries.

- Super-capacitors have more life time than batteries.
- It reduces environmental impact.
- It is rugged, reliable and maintenance free.
- It has excellent low temperature characteristics.
- Super-capacitors can be manufactured in a smaller size for a given capacitance and shape.
- A super-capacitor can be used to store the required current and deliver it quickly without draining the main battery.
- There is no danger of overcharging, when fully charged the super-capacitors simply quit accepting a charge.
- Super-capacitors are not affected by deep discharges as are chemical batteries.
- It reduces maintenance cost.

7.2 Disadvantages

- Super-capacitors do not support AC applications.
- Super-capacitors have high self-discharging.
- Voltage balancing needed.
- Ultraviolet effect is high.

Super-capacitors are more expensive than batteries.

VIII. FUTURE SCOPE

• In future the batteries will totally replace by super-capacitors.

• This will be more advantageous in the rural areas.

• Laptop, emergency light, car batteries, mobiles etc. the super-capacitor will be used.

IX . CONCLUSION

- Due to flexibility super-capacitor can be adapted to serve in various roles.
- Super- capacitor have great potential for applications that require a combination of high power, short charging time, high cycling stability.
- Super- capacitor are ideal energy storage for UPS systems due to their exceptionally long cycle life, high reliability, high efficiency, high power density, ease of charging & excellent low temperature performances.
- Super-capacitors are used in wind turbine, energy harvesting, medical field, street light, transport system, military application etc.
- Super-capacitor decreases the charging time so it can be used in place of battery.

ACKNOWLEDGMENT

We wish to express our heartiest thanks to Director **Dr.M.P.Singh,** for providing us the guidelines to start this paper and the students who helped us a lot.

REFERENCES

Websites

- http://www.google.com
- http://www.wikipedia.com

Books

- Super-capacitor : A brief overview by Marin S. Halper & James C.Ellenbogen ,MITRE Nanosystems Group
- Design of battery - Super-capacitors combination in uninterruptible power supply by IJ.S.E.R.
- Simple capacitor to Super-capacitor - An overview by M. Jayalakshmi ,K B alasubramanian.
- Super-capacitor basics and applications by Kai Vuorilehto & Matti Nuutinen.
- Comparison of Different type of carbon material as electrodes of super - capacitor by IJ.I.R.S.

AUTHOR'S PROFILE-

First Author- ***Mrs. Shalini Kumari***[1]

Currently working as an **Assistant Professor** at **R.V.S.C.E.T,Jamshedpur** and pursuing **P.hd (Electronics and communication engg.)** from **B.R.A university.**Have done **Post Graduate** in **Information Technology** from **Birla Institute of Technology , Mesra** , **Ranchi** and **B.E (Electronics & Telecom)** from S.**S.G.M College of Engg. (Amrawti University).**Was published a **paper** on **Energy management from waste at affordable** rate at **Bihar research journal,Issue-11,Jan-June 2014,ISSN:0975-4288.**

SecondAuthor-*Mrs.Neha Shrivastava*[2]

Have completed **M.Tech(VLSI)** from **B.U,Ajmer** and **B.Tech** from **N.I.S.T,Berhampur** in **Biju Patnaik University Of Technology,Rourkela.**
Presented Two **National Papers** and have attended one **International** and **one National Confrences**.Certified in **Core Java"SUN certified".**Worked as an **Assistant Professor at M.G.E.C,Jaipur and R.V.S.C.E.T,Jamshedpur.**