

# Applications Of Ultra Capacitor In Indian Vehicles

Vishnu Kokate, RM Holmukhe, PB Karandikar, Saurabh, Nidhi Yadav

**Abstract:** Presently self-start two-wheelers, including motorcycles and scooters between 50 - 200 cc capacities, use standard lead-acid battery of 5, 9 and 12 Ah rating as the energy source. A battery is a well-known energy source, but it cannot supply a large amount of power in a short time. The size of the battery is decided based on the starter motor requirement. Further, deep discharge at the time of cranking reduces the life of the battery drastically as compared to normal use. Also, an extra factor of safety is provided for cold weather cranking performance, poor maintenance and end of live performance in view of deep discharge. Hence the battery becomes heavy and bulky. On the other hand, Ultra-capacitors can supply a large burst of power for short time but cannot store much energy, hence a limited number of starts. Decentralized Ultra-capacitors network is another major advantage in the future of automobile sector.

**Index Terms:** Battery, Solar-Panel, Self-Start, Ultra-Capacitors, two-wheeler, Decentralized Network,

## 1. INTRODUCTION

In the recent past, with the increase in purchasing power of Indian customer, preference for two-wheelers fitted with Starter Motor is on the increase. More than 25% of the two-wheelers manufactured, that is about 2 million two-wheelers manufactured till 2007, are with the starter motor. Also, two-wheelers of more than 150cc are fitted with starter motor as kick-starting and such engine is physically demanding on the part of the customer [1],[2]. In response to the changing global landscape, energy has become a primary focus of the major world powers and scientific community. There has been great interest in developing and refining more efficient energy storage devices. There is various electrical power storage device but, the battery is the most common electrical storage device used in vehicles [3]. Ultra-capacitor is one of the power storage devices used in vehicle hence it has emerged with the potential to facilitate major advances in energy storage. Ultra-capacitor is a new technology in India as compared to developed countries. It is pulsed current device and it can be used in almost all automobiles which are operating on the conventional energy source [4]-[6]. Ultra-capacitor technology is emerging technology in which very few scientists are working around the globe. USA, Germany, Australia have taken initiative in this research area. Maxwell, Evans, Epecos are only a few companies of USA, Europe, China, Japan in the world who have commercially made this product available in the market. Vehicles like two-wheelers are being the best transportation for a common man in developing countries like India .For starting various types of two-wheelers, initially kick is use but during the kick, knee gets a sudden jerk which harms knee. For overcoming these tremendous problems, battery-

based /button start has come into use, but battery life, cost and size, and maintenance are main issues [7],[8]. During key starting pulse current of high magnitude and short duration required, it is supplied by over rated battery, but it increases the cost of the vehicle. Ultra-capacitor is a high faradic value which is capable of delivering a large amount of current by connecting parallel with the battery [9].

As the name suggests it is a capacitor with large capacitance. It polarizes an electrolytic solution to store energy electro statically. Though an electrochemical device, no electrochemical reactions are involved in its energy storage mechanism [10]. This mechanism is highly reversible and allows the Ultracapacitor to be charged and discharged hundreds of thousands of times, without any appreciable loss in its capacitance. Electrochemical Double Layer Capacitors (Ultracapacitor/Ultra caps/Super capacitor), with its short charging & discharging time, is ideally suited for the intermittent loads [11]. Starting with the introduction of 'Coin/Button Cells' in the '80s to the present mega-ultra-capacitor units, the industry has come a long way. In the '80s and '90s, manufacturing of Ultra-capacitors was primarily an art. With the advance in technology, automated assembly techniques have replaced the labor-intensive aspects of manufacturing. As a result, costs have decreased substantially.

**Table 1.**  
Comparison of Ultra-Capacitor and Battery.

Parameter	Ultra-Capacitor	Battery
Expected life, years	More than 20	1 to 3
Charge-discharge cycles	More than 500,000	1000
Power density, W/Kg	4000	300
Energy density, Wh/Kg	3 to 5	80 to 100
Charge control	Not needed	Needed

- Vishnu Kokate is currently a research scholar in Dept. of Electrical Eng. in Bharti Vidyapeeth (Deemed to be University), Pune, India. E-mail - [vlkokate@gmail.com](mailto:vlkokate@gmail.com)
- R M Holmukhe is Associate Professor in Dept. of Electrical Eng. in Bharti Vidyapeeth (Deemed to be University), Pune,, India. E-mail – [rajeshmholmukhe@hotmail.com](mailto:rajeshmholmukhe@hotmail.com) and [rmholmukhe@bvucoep.edu.in](mailto:rmholmukhe@bvucoep.edu.in)
- P B Karandikar is Asso Professor in Dept. of in Electronics and Telecommunication in Army Institute of Technology, India. E-mail: [pbkarandikar@gmail.com](mailto:pbkarandikar@gmail.com)
- Saurabh is currently pursuing Bachelors degree program in Electronics and Telecommunication engineering in Army Institute of Technology, India. E-mail: [imsaurabhg99@gmail.com](mailto:imsaurabhg99@gmail.com)
- Nidhi Yadav is currently pursuing Bachelors degree program in Electronics and Telecommunication engineering in Army Institute of Technology, India. E-mail: [ynidhi.to@gmail.com](mailto:ynidhi.to@gmail.com)

Ability to discharge completely	Yes	No
Self-discharge	High	Low
Flat discharge curve	No	Yes
Maintenance free	Yes	No
Weight	Less	More

			capacitor is charged more.
3	Activa	10-11Times	If the magneto of the active vehicle is modified as above it will start more number of times.
4	Street	11-12Times	Rating of the motor is low as compared to other vehicles

## 2 ULTRA-CAPACITORS IN IGNITION

An ignition system generates a spark or heats an electrode to a high temperature to ignite a fuel-air mixture in spark ignition internal combustion engines. For Two-wheeler ultra-capacitor bank will be tried as a replacement to the battery in its current state. For this various electronic circuits will be tried. OPAMP based or Power electronic-based circuits will be built to interface battery, ultra-capacitor, dynamo or magneto along with starter motor and other loads in the automobile. For three wheeler E-rikshaw BLDC Starter motor run on a combination of a battery bank and Ultra-Capacitor bank connected in parallel to each other and supply power to BLDC motor. With help of monitoring kit at starting of the motor, Ultra-Capacitor will connect and provide power to the motor. and at running condition, Ultra-capacitor disconnect and battery will run the motor, This way we will reduce the starting electric stress of battery and increase the performance of the battery. For two-wheeler vehicles, Each individual capacitor bank is having 6 Ultra-capacitors connected in series. Rating of each Ultra-capacitor is 58 F, 2.7 V. One capacitor bank is connected instead of Battery for starting the BLDC motor/ to start the vehicle. Readings are noted down for vehicles of various make and analysis of reading is done to identify which make/company of vehicle can be started for how many numbers of times on full charge of Ultra-capacitor bank of 16.2 V. In two-wheelers when Ultra-capacitor and Battery combination is used as a power source, both supply the power to the BLDC starter motor. In existing two-wheeler system battery size is needed to be kept large to withstand the high starting electric stress. When Ultra-capacitor and Battery combination is connected in parallel and used for starting the vehicle, both share the starting current, as in parallel connection starting current gets divided. The thus smaller sized battery can be used and battery cost can possibly be reduced approximately up to 50%.

**Table 2.**

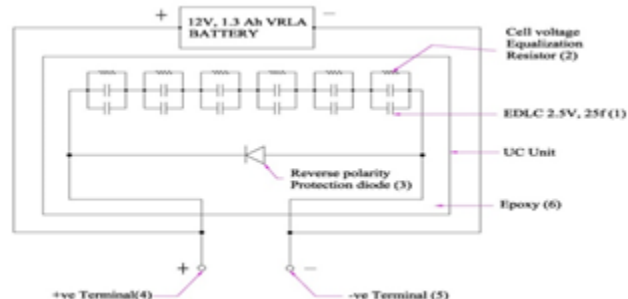
*Observation on start time of various vehicles.*

Sr. No.	Name of vehicle	No of Start on full charge of Ultra-capacitor bank(16.2V)	Analysis/ Justification/ Remark
1	Auto Rickshaw	2 Times	The motor takes more power at the initial time and thus ultra-capacitor discharges immediately
2	Shine Bike	8-9 Times	Modification is done in magneto coil by increasing the turns of starting coil, thus the coil will produce more voltage & ultra-

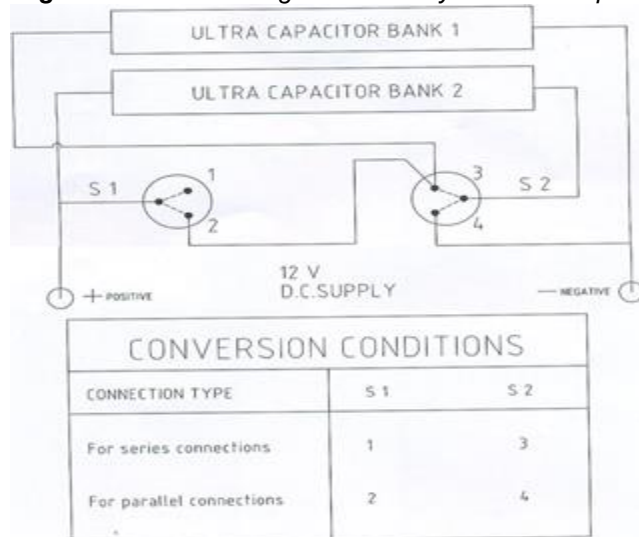
## 3 DESIGN AND DEVELOPMENT OF SYSTEM

### 3.1 Series-Parallel conversion circuit

We developed a series parallel circuit, which can connect two Ultra-capacitor banks in series or parallel as per requirement. Initially, at the time of starting the vehicle, Ultra-capacitor banks are connected in parallel and then later during working of the vehicle when its voltage falls below 12V i.e. the rated voltage range, ultra-capacitor will be connected in series to get double voltage due to two Ultra-capacitor banks. In this situation of series connection of two ultra-capacitor banks total voltage gets added and as the result, more voltage is available at the output. Thus, the vehicle can be started a greater number of times than earlier when the ultra-capacitor banks are in parallel. This is a very effective method to withstand the voltage value of Ultra-capacitor because voltage level is maintained at rated value, hence motor will start a greater number of times as compared to the previous number of times. The diode is used to protect the ultra-capacitor from reverse polarity of battery supply. Rating of battery is 12V which is connected across the ultra capacitor bank. Rating of each ultra-capacitor is 2.7V and 25F.S



**Fig.1.** A basic block diagram of Battery and Ultra-capacitor



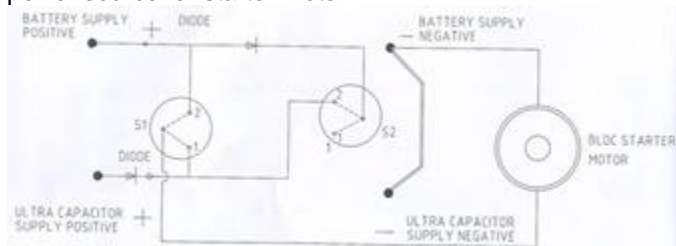
**Fig.2.** Developed series-parallel circuit

Vehicle will be started using both ultra-capacitor banks, later the Battery and Ultracapacitor pack will be combined to check

the easiness of starting of the vehicle. UC-1 and UC-2 are the Ultra-capacitor banks, which can connect it in parallel initially by making S1 switch at position 1 and S2 Switch at position 3. As a result, both UC banks will be connected in parallel and supply power to BLDC starter motor. During working condition, after some time UC banks get discharged, its voltage level falls below the required range and BLDC starter motor cannot start. At this situation change the position of S1 at off and S2 at 2 positions, thus both UC banks get connected in series to get additive voltage of both Ultra-capacitor banks, as a consequence BLDC starter motor can be started a greater number of start times than the previous number of start times

**3.2 Manually operated source selection circuit**

With the manual circuit, we can select Ultra-capacitor instead of Battery as a source at the time of starting, thus avoiding the electric stress on battery. During the running condition, Ultra-capacitor is disconnected and battery will be connected as a power source for starter motor.



**Fig.3. Manually operated circuit**

This circuit can be used where two sources like Ultra-capacitor and Battery are use as power source for starter motor. Initially, Ultra-capacitor is connected to starter motor, to avoid high heavy electrical current stress on battery during starting. By using this arrangement, study can improve the performance of the battery, increase life of battery and reduce the cost of battery.

**4 OTHER APPLICATIONS OF ULTRA-CAPACITORS IN VEHICLES**

We developed a system which is a combination of solar and ultra-capacitor. This system is used for providing power to horn, blinker and brake light in any type/make and any load of automotive vehicle. When sun rays falls on photovoltaic cell, solar energy is converted into electrical energy and it is used for charging of Ultra-capacitor at rated value which supply power to the Horn, Blinker and brake light. All these three are movement/ temporary applications. Thus Ultra-capacitor works as a useful power source for movement applications. A charge controller is used in between solar panel and ultracapacitor to provide a constant output voltage to ultracapacitor, thus avoiding the effect of variation of input voltage provided by solar panel. In this study, the system uses 12 V solar panel which is connected to Ultra-capacitor bank ( in which 6 Ultracapacitors are connected in series, each rating is 58 F, 2.7 V).

**Table 3**  
*Typical Loads on a battery*

Load	ON 5Ah Battery (W)	ON 9Ah Battery (W)	Remarks
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Horn	24	24	Safety feature
Direction Indicator	21.7	21.7	Safety feature
Brake indicator lamp	20	20	Safety feature
Dash Board Neutral indicator	1.7	1.7	Indication
Starter Motor	150	350	Functional
Total	216.4	417.4	

**5 CONCLUSION**

From the field trials and experiments on designed and developed circuits, it can be concluded that Ultra capacitor as a Battery substitute matches all performance requirements during the investigations of the study. The concept of 'Kick-Start' of two-wheelers can be completely removed because battery along with ultra capacitor can overcome the shortcomings faced during vehicle starting which were affecting the life of battery. When the battery-ultra-capacitor combination is connected in automotive system at the time of starting it will connect Ultra-capacitor as a power source to avoid high current stress of battery during starting and in running condition Ultra-capacitor is disconnected and battery will be connected as a power source. The vehicle users are benefited with the safety features operational at all times throughout the life of the vehicle without battery maintenance hassles and cost of periodic replacement of Battery. This added value along with the safety aspect justifies the higher initial cost of Ultracapacitor over the lead acid Battery. The designed circuit after implementation can also contribute towards Lead-free Environment. As a result of experiments and field study of electric vehicle systems across different brands of vehicle it can be concluded that Battery-Ultra-capacitor combination can be used as a direct substitute to a battery, without any modification for over 80% of the existing Kick-Start vehicles. It can be concluded from the study that it is possible to start the vehicle by using Ultra-capacitor alone instead of battery. The nature of ultra-capacitor is quick charge and quick discharge, due to which, it is used only in momentary application in automotive systems. It is also clear from the analysis of results that when the battery & ultra-capacitor combination is used as a power source of vehicle, the heavy starting current of starter motor is faced by ultracapacitor, therefore avoiding the electric stress of battery and as a result will increase the performance and life of battery and reduce the cost of battery by 20 to 30% approximately. It can be concluded that when ultra capacitor bank is used at the time of starting the vehicle, it can supply large burst power for starting the vehicle. Additionally, by using ultra capacitor with battery at the time of starting the vehicle avoids the deep discharge of battery. Further, the combination of ultra capacitor and battery can make ultra capacitor to supply maximum peak demanded power to the motor and protect the battery from large starting current of motor therefore and a consequence battery size is reduced, making it possible to replace downsized battery in the place of existing large size battery. This makes the working of combination of ultra capacitor and battery economical, battery size is reduced, battery becomes maintenance free, low weight and having

good cold start capability. In this study the issue of proper selection of ultra capacitors is significant.

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