Analysis of integration of battery and UC for EV

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Abstract

Pollution and continuously increasing rates of fossil fuels, the vehicle running on electricity are gaining attention. Electric vehicle can be run by supplying by on grid such as electric locomotive or by storing electric energy in rechargeable storage devices. The electric vehicle needs a storage device which is energy denser as well as power denser. Only one type of source cannot provide the above requirements of drive, hence, an answer for this problem is to use various energy storage devices. The aim of this action is to overcome the disadvantage and make each device useful to provide sufficient energy.

Keywords: Hybrid storage, Battery, Super capacitor, Electric vehicle, integrated storage.

1. Introduction

Along with batteries, the research for storage solutions is continuing on super capacitors, fuel cells and flywheels. High specific power, high specific energy, long life cycle with safe operation in all road condition are the requirements of energy storage devices. Fuel cells and flywheels cannot be the solution due to their drawbacks such as short storage capacity and safety constraints. Batteries cannot provide instant power to vehicles though it can provide high specific energy. Size of super capacitors becomes bulky to provide same amount of energy given by batteries. Hence, the integration of super capacitors with batteries is an accepted solution to improve the energy density and power density simultaneously, because, battery is with high energy density and low power density and Super capacitor is known for its high power density, cycle lifetime, cycling efficiency and low energy density.

2. Battery

Battery is most frequent method used to store electrical energy in transportation automobiles. It is a popular way to store energy due to their capacity of storing large amounts of charge comparatively small volume and weight. Battery can provide power at suitable levels for many utilization purposes.

Lead-acid battery were the first choice for electric vehicles as they are oldest and cheaper in price. But the energy density is low for lead-acid battery. It produces some toxic gases during internal chemical reaction. Nickel metal hydride comes in late 80s with high energy density. They also don’t release toxic gases.

Nickel- cadmium batteries were in competition with lead acid since 1900. It’s advantage is high discharge rate and good cycle life. But due to presense of heavy metal Cadmium, many countries banned nickel-cadmium battery.

In 1990s, the lithium-ion battery came into picture with high energy density, eco-friendly. But there is one more thing called self-discharge that is the process of reduction in stored charge without connecting load to electrodes. Self- discharge rate of Ni-MH battery is almost 12.5% per day while the Li-ion battery have 2-3% per month. Lighter weight, smaller in size are the additional points which makes Li-ion battery as a preferable choice.

	Lead-acid	Ni-MH	Ni-Cad	Li-ion
Energy density (Wh/L)	60-110	140-300	50-150	250-693
Self-discharge rate (%/month)	5	10-15	10-15	2
Specific Power (W/Kg)	180	250-1000	150	250-340
operating temperature (°C)	-20 to +50	0-45	0- 45	0- 45
Cycle life	<350	180-1000	2000	400-1000
Cost ($/KWh)	100	18.5	7.5	350

TABLE 1. COMPARISON BETWEEN TYPES OF BATTERIES.

3. Super capacitor

Ultracapacitor or super capacitor is an electrochemical capacitor which constructed to act as a battery containing two electrodes immersed in an electrolyte solution with a porous separator between electrodes to separate them from each other. The separator is made up of polymers or product of nano-particles such as Graphene. The requirement of minimum energy storage decides the weight of super capacitor. The cycle of charging-discharging and the power of ultracapacitor are satisfying. This shows that super capacitor can be more precise solution for many applications with lesser weight than battery even its energy density is nearly one-tenth of the battery.

Constant Current discharge 3.8V – 2.2V

Current (A)	Time (sec)	C(F)
20	86.4	1096
40	41.9	1078
60	27.2	1067
100	21.4	1063
	15.7	1057

** resistance is steady-state value from linear V vs. time discharge curve

Constant Power discharges 3.8V – 2.2V				
Power (W)	W/Kg	Time(sec)	Wh	Wh/Kg
50	347	106.7	1.47	10.2
83	576	61.9	1.43	9.9
122	847	40.1	1.36	9.4
180	1250	26.2	1.31	9.1
240	1667	19.1	1.27	8.7

* based on the measured weight and volume of the cell as tested.

TABLE 2. CHARACTERISTICS OF THE JSRMICRO 1100F ULTRACAP CELL

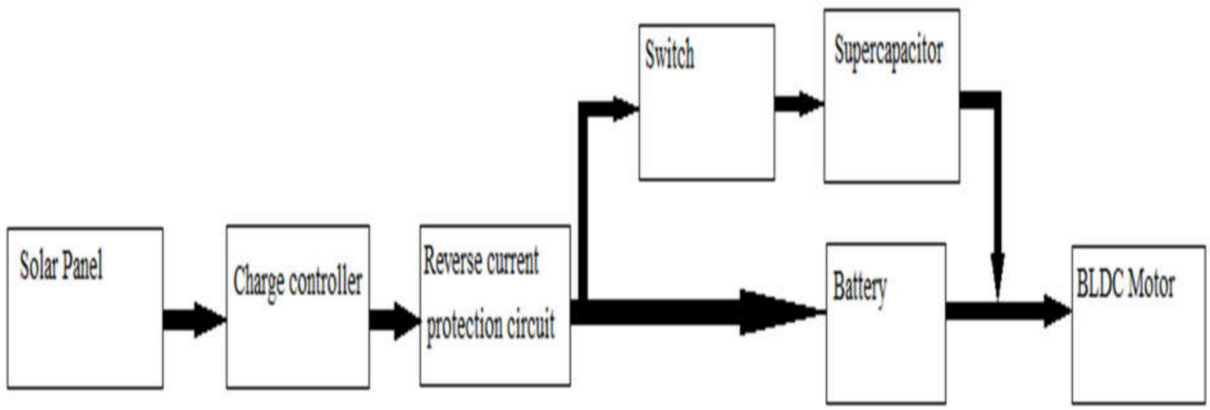
4. Integrated storage.

Batteries have been the technology of choice for most applications, because they can store large amounts of energy in a relatively small volume and weight and provide suitable levels of power for many applications. For electric vehicle, batteries are considered as preferable storage device. But battery have low charging and discharging rate.

This disadvantage can be overcome by integrating batteries with other storage devices like flywheels, fuel cells, ultracapacitor, etc. Fuel cell and flywheel are not sufficient yet to supply all needs of vehicles due to limited storage capability, safety and operational constraints, while the super capacitor is a very high power density device.

The function of the super capacitor is to enhance high current demand from the energy source. The battery provides the continuous power while the UC provides peak powers.

Energy in battery is in chemical form and in super capacitor, energy is in physical form. There is reversible reaction takes place in battery while charges are separately stored in super capacitor. Super capacitor have an excellent life cycle with the high cycle efficiency, because, the state of charge (SOC) in the super capacitor is directly proportional to the terminal voltage, There must be a limited operating voltage to control varying voltage electronically.



This is the design of the integration of battery and super capacitor for electric vehicle by connecting them in parallel to each other. This integration of storage devices will overcome the disadvantages of each one and increase overall performance of storage unit.

The charge controller will deliver the current required to the load from solar panel limiting to maximum value otherwise battery will explode. Battery reversal can be fatal to charge controller or panel. Hence for protection against the backward flow of current we used reverse current protection circuit. Other than reverse current protection, overcharge and over voltage protection are also used here.

5. Conclusions

The high acceleration demand of electric vehicle causes high current demand from the energy source. The function of the super capacitors is to enhance the demand. Super capacitors satisfy the demand of high current. This will help to keep discharging current in limits and life cycle of battery will be extended.

An algorithmic procedure is followed to decide power management of the system. The principle operation is as follows:

(i)The demand current is developed at high acceleration from the super capacitors.

(ii) For longer battery life, it provides a current at a recommended rate.

(iii) The peak current demand is fulfilled by the super capacitor.

The battery provides the required continuous power while the super capacitor provides peak powers. A power exchange between battery and ultracapacitor allows to acquire high regenerative powers and to deliver high power for acceleration. This exchange results in a more effective use of energy storage devices and increases the driving range.

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