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Hybrid Energy Storage System

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Abstract: This paper describes about the energy storage technology. As the most important problem of today's world is energy crisis, so deal with this problem here we have presented our paper on hybrid energy storage system. This system is basically designed to store energy and use it according to our requirement and provide energy management. An energy storage system consists of first stage energy storage device such as a secondary or rechargeable battery, and a second stage as an another energy storage device such as a capacitor, fuel cell. The second energy storage device provides intermittent energy bursts to satisfy the power requirement, for example, pulsed power communication devices. Such devices require power pulses in excess of those which conventional battery cells can easily provide for number of cycles. The system further includes circuitry for coupling the second energy storage device to a load in response to changes in the battery.

INTRODUCTION

This paper relates in general energy storage, management and in particular to hybrid rechargeable energy storage devices which provide high power and high capacity for portable electronic device. And help to conserve energy for further use. As further in this paper we will discuss how we can conserve energy and energy management taking vehicles as our consideration. As we are growing towards advancement demand for compact and renewable resources are increasing. Consumer demand for portable electronic devices with more functional features. We can take the examples of such devices which include two-way and broadcast radio receivers, compact disc players, cellular telephones devices to name but a few. As the electronic devices have reduced in size the demand for smaller energy sources, such as batteries, to power such devices has increased. Very small energy storage devices, such as an electrochemical battery cell, may be fabricated for a given electrical device; however as the compactness increases the cost of energy capacity also increases. Accordingly, for many high power applications the energy source is too bulky, too heavy, or doesn't last long enough. The energy storage device, such as a battery, is discharged, it becomes unable to provide current according to requirement .Even though the battery may retain a substantial charge, and it is useless to the device to which it is attached. This problem is exacerbated when the device to which the battery is attached requires high power. In Such case power pulses or spikes require, solution to this was that user may carry portable, high speed, charging devices with them. But however this was unacceptable, because of additional weight of charging device. Therefore, what was needed was an energy source which is capable of providing sufficient power for the high power pulses required by the devices, with extending the usable life of the energy source. Such a device should be relatively small, and capable of being easily sized and shaped for a given application. Such a device should be able to recognize charging internal conditions, and alter its

response as a function of the charged condition. An energy storage system consists of a first energy storage device which consists of a battery having impedance for providing a substantially constant power output; a second energy storage device provide intermittent bursts of high voltage output; and
circuitry responsive to changes in battery impedance, and controlling a switch for electrically coupling according to second energy storage device to a load, said circuitry comprising a pair of resistors electrically coupled to a controller and said controller electrically coupled to said switch. Use of renewable energy sources is increasing which mostly include wind turbine and solar energy. Both have their own limitations over time period, these facts generates stability, reliability and power quality problems in the main electric grid. So that microgrid is being analyzed as a feasible solution for these problems.
A microgrid is formed by micro sources, storage systems, power converters and loads. It can either be used connected to main grid and in isolated mode .Hence, it can overcome the availability at irregular intervals. In this context, the use of the ESS is a widely accepted idea, as it has solution of various problems. Because of high sensitivity microgrid required high energy and power density. No ESS can provide these features and hence two or more Microgrid are connected together, creating a Hybrid Energy Storage System (HESS). The HESS formed by two complementary storage devices, one of high energy density and the other of high power density. The unique type of ESS are slow because they are usually of high energy density and but low power density. High load demand reduces the life cycle of storage system. On adding short storage system in parallel to a long-storage

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reduces the size and power loss. By this paper we can see that HESS formed by a VRB and a Super Capacitor (SC) is Compared the results show that for the same wind-power profile the maximum power for the VRB in the HESS is less than the half of that in the unique ESS. The VRB depth of discharge is 5-8% less in the HESS and the power losses referred to the storage are also reduced in 15%.Similar results are obtained. The size of a reversible fuel cell and a battery are reduced in 75% and 64% respectively. The power converters are used to minimize the interfaces between the ESS and the microgrid, to control the power flow of the storage Device .HESS creates new issues related to the energy management: the power division among the different storage devices and their coordination to satisfy a shared requirement, HESS should have proper size to obtain an optimum utilization of the whole system and to get the good efficiency. The presence of fossil fuel will not last for more than 50 years if consumed by present rate, so the use of hybrid energy storage should be encouraged in areas where large portion of fossil fuels is used i.e. Trains. And in HEV's (hybrid energy vehicles) the overall performance is improved i.e. fuel efficiency, emission reduction etc. And its characteristics include energy density, power density, lifetime, cost, and maintenance.

Current options for ESS (energy storage system) are –

1. Ultra capacitors due to high power densities and a long life cycle with high efficiency and a fast response for charging/discharging.
2. Batteries due to high energy densities and store the majority of onboard electric energy.
3. Fuel cell (FC) is another clean energy source; however, the long time constant of the FC limits its performance on vehicles.

However each has its drawbacks and cannot meet all the requirements alone for HEVs.

As stated earlier due to high power density and long life time batteries are used. And this section compromises with types and advantages of Batteries.

1: Lead-Acid batteries:

The lead acts as the negative active material of the battery, lead oxide is the positive active material, and diluted sulphuric acid is the electrolyte, both positive and negative materials are transformed into lead sulphate for discharging. Low cost and matured technology are the advantages of this type of batteries. The lead–acid battery is not suitable for discharges over 20% of its rated capacity. Hence, limited life time, heavy weight of collectors, reduced energy and power densities are its main drawbacks however with improvement in collectors (using non-corrosive collectors) can improve energy density.

2: Nickel–Metal Hydride (NiMH) Batteries:

In NiMH battery nickel hydroxide is on the positive electrode, and the negative electrode is made of engineered alloy of vanadium, titanium, nickel, and other metals. The energy density of the NiMH battery is twice that of the lead–acid battery, It can be operated at high voltage and has distinct advantages, such as storing volumetric energy and power, long cycle life, wide operation temperature ranges, and a resistance to over-charge and discharge. The best operation performance is achieved when discharged 20% to 50% of the rated capacity. The repeated operation at high load current reduces its life by 200-300 cycles, the usable power for the HEV and hence usable SOC of the battery is reduced due to memory effect in NiMH. The components of NiMH are eco-friendly and recyclable.

3: Lithium-Ion (Li-ion) Batteries:

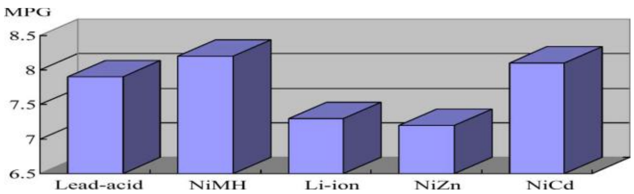
In Li-ion batteries the positive electrodes made of an oxidized cobalt material, and the negative electrode is made of a carbon material. The lithium salt in an organic solvent is used as the electrolyte. It have many advantages over NiMH batteries such as Low memory effect, high specific power of 300 W/kg, high specific energy of 100 Wh/kg, long battery life of 1000 cycles and the cost of NiMH batteries is high (about \$1500/kWh), energy density of Li-ion batteries is twice of NiMH, which are priced at \$750 to \$1000/kWh.

4: Nickel–Zinc (Ni–Zn) Batteries:

They have high energy and power density, low-cost materials, and deep cycle capability and can be operated in temperature −10 ◦C to 50 ◦C, which means that they can be used under severe working circumstances. Poor life cycles due to the fast growth of dendrites, which prevents the development of Ni–Zn batteries in vehicular applications.

5: Nickel–Cadmium (Ni–Cd) Batteries:

Long lifetime and can be fully discharged without damage. The specific energy is about 55 Wh/kg. These batteries can be recycled but cadmium is a kind of heavy metal that could cause environmental pollution if not properly disposed of. Its cost is high, usually, it will cost more than \$20 000 to install these batteries in vehicles



Fuel Economy (miles per gallon) comparison on different batteries.

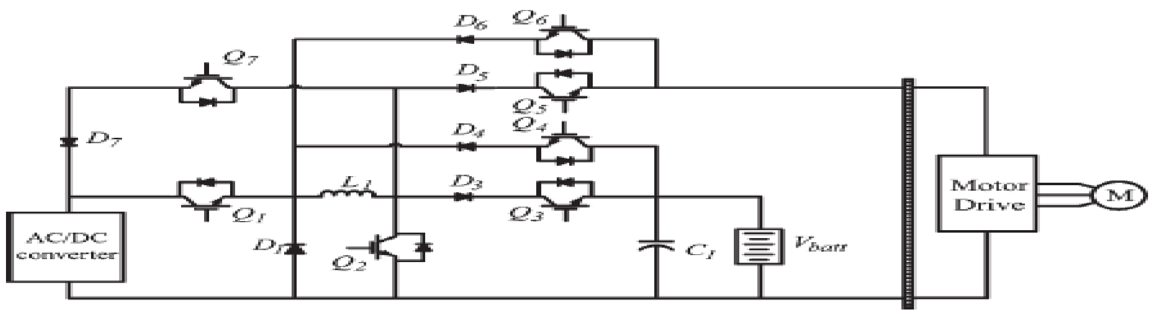
Ultra Capacitors:
In UC energy is stored by physically separating positive and negative charges on two parallel plates divided by an insulator. Due to no chemical variations on the electrodes it haves long cycle life but low energy density. The applied potential on the positive electrode attracts negative ions and negative electrode attracts positive ions. Due to the fact that the charges are physically stored on the electrodes, power density of the UC is higher than that of the battery. And because of Low internal resistance its efficiency is increased. But charging at very low SOC large bursts currents is obtained at output. UCs can be used as assistant energy-storage devices for HEVs. In urban driving, there are many stop-and-go driving conditions, and the total power required is relatively low. UCs are very appropriate in capturing electricity from regenerative braking and quickly delivering power for acceleration due to their fast charge and discharge rates. Batteries have high energy density, whereas UCs has higher power densities. Long lifetime and low maintenance lead to cost savings.

In HEV applications, both batteries and UCs could be combined for efficient use. There are five UC technologies in development: carbon/metal fiber composites, foamed carbon, a carbon particulate with a binder, doped conducting polymer films on a carbon cloth, and mixed metal oxide coatings on a metal foil. Higher energy density can be achieved with a carbon composite electrode using an organic electrolyte rather than a carbon/metal fiber composite electrode with an aqueous electrolyte.

Fuel cells:
In FC electricity is generated by the fuel on the anode and the oxidant on the cathode and reacts in the electrolyte. The reactants flow into the cell and the products of reaction flow out. In FC electricity can be generated as long as the reactant flows are maintained. Hydrogen having highest energy density than any other fuel and being non polluting makes it ideal fuel. Its by product is water. Other fuels include hydrocarbons and alcohols, and other oxidants include chlorine and chlorine dioxide.

Hybrid Energy-Storage Systems for Vehicular applications:
The most of the commercially available HEVs ESS consists of only battery packs with a bidirectional converter connected to the high-voltage dc bus. Commercially available examples are -Toyota Prius, Honda Insight, and Ford Escape HEVs with efficiencies around 40 mi/gal in the market. Topologies to hybridize ESSs for EVs, HEVs, FC hybrid vehicles (FCHVs), and PHEVs have been developed to improve miles per gallon efficiency. Various topologies (combining energy sources with different characteristics), with one common feature, which is to efficiently combine fast response devices with high power density and slow response components with high energy density. For battery/UC systems, bidirectional dc/dc converters are widely used to manage power flow directions, either from the source to the load side for acceleration or from the load side to sources during regenerating periods. The battery pack is directly paralleled with the UC bank. A bidirectional converter interfaces the UC and the dc link, controlling power flow in/out of the UC. Despite wide voltage variation across UC terminals, the dc-link voltage can remain constant due to regulation of the dc converter. However, in this topology, the battery voltage is always the same with the UC voltage due to the lack of interfacing control between the battery and the UC. The battery current must charge the UC and provide power to the load side. The voltages of the battery and the UC will be leveled up when the drive train demands power and stepped down for recharging conditions. Power flow directions in/out of the battery and the UC can separately be controlled, allowing flexibility for power management. However, if two dc/dc converters can be integrated, the cost, size, and complexity of control can be reduced.

Plug-in FCHV:
In this system, the FC is interfaced by a boost converter with the dc link, which boosts the FC voltage to a higher level. Batteries are connected to the dc link via a bidirectional converter to supply and absorb regenerative energy. PHEVs have been proposed to extend the all-electric driving range of HEVs .Researchers are investigating the novel topology of the battery integrated with the bidirectional ac/dc–dc/dc converters for PHEVs.



Bidirectional dc/dc converter integrated with an ac/dc converter.

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The proposed topology in Fig. 13 could be operated in four modes: charging/discharging the battery from/to the grid and bidirectional power flow between the battery and the dc link. Adding UCs to ESSs of EVs, HEVs, and PHEVs will help reduce battery size and extend battery life. The hybridized ESSs are being investigated for a future generation of PHEVs, EVs,and HEVs.

Combining UCs with batteries would also improve fuel efficiencies, extend all electric driving ranges, decrease greenhouse gas emissions, and improve the life of the battery packs. When operated in a high frequency, a fairly small transformer can be used. Zero-voltage switching is achieved by operating the two half-bridges with a phase shift. This operation allows a resonant discharge of lossless snubber capacitances of switching devices. Each antiparallel diode is conducted before the conduction of the switching device. The circuit operation uses the transformer leakage inductance as an interface and energy transfer element between the two half-bridge converters. PV–Diesel, PV–Wind, PV–Wind-Diesel, and Wind–Diesel hybrid systems with energy storage in batteries have been studied. There is a probabilistic model in reference to the simulation of Wind–Diesel systems (no batteries) based on the use of statistical data of loads and wind speeds. Additionally, restrictions are usually included that are applied to reliability, evaluating the same by means of one of the following parameters:

1: Loss of Load Probability (LOLP):
2: Loss of Power Supply Probability (LPSP)
3: Unmet Load (UL)
4: **Zero-charge strategy (Load Following Diesel)**
5:**Full cycle-charge strategy**

CONCLUSION

This study is carried out on various technologies taking into consideration the optimum use of energy, energy management and storage of energy so that the we can use energyin a sustainable way it has been proved that these technologies are widely useful and cost effective so the must be taken into practice.

- EVs, HEVs, FCHVs, and PHEVs are effective solution for current energy and environment concerns.
- Revolutionary contributions of power electronics and ESSs, electric drive trains totally or partially replace ICEs in these vehicles. Single ESS devices such as batteries, UCs, and FCs could not meet all the requirements of advanced hybrid electric drive trains individually. Researchers are investigating hybrid ESSs with large capacity, fast charging/discharging, long lifetime, and low cost.

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