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# Review on Ultra Capacitor- Battery Interface for PV Systems Using MPPT Controller

**M. Tech. Scholar Altamash Adil, Asst. Prof. Bhanu Pratap Singh**
Department of Electrical Engineering,
A.N.A College of Engineering & Management,
Bareilly, UP, India

**Abstract- Electrical energy storage is an important part of any electric-drive technology, whether it's hybrid, fuel cell, or all-electric. The high cost of replacing battery banks that have run out is a big cost with energy storage. One way to lessen the load on batteries and fuel cells is to use ultracapacitors as load-leveling devices. Here, we look at the technology and challenges of the ultracapacitor-Battery interface for an energy management system. We also look at the related research work.**

**Keywords- Energy Management, Ultracapacitor- Battery, AC-DC converter, hybrid electric vehicles (HEV).**

## I. INTRODUCTION

Electricity is the most important commodity in any country or country's social and economic development. It plays an imperative role in all human behavior in the current situation. The majority of electricity comes from fossil fuels such as coal, oil or natural gas. These fossil fuels have a serious impact on the atmosphere in many ways. Even these fossil fuels are limited and will continue until the middle of this century. Need to implement renewable energy (RES) for green energy.

Solar panels are the means by which solar energy is converted into electrical energy. Solar panels can either transform the energy directly into usable form or use the induced energy to heat water. As with computer technology, PV (Photovoltaic) cells contain semiconductor architectures, which are similar to that of solar cells. Because of the absorption of sunlight by this material, electrons from the atoms to which it is linked can be seen emitting from them.

A current is activated as a result of this release. Photovoltaics are defined as the process that occurs between the absorption of a light beam and the generation of energy. Solar power is converted into electric power with a common principle and individual components. Solar batteries are produced by waffling p-n semi-conductors.

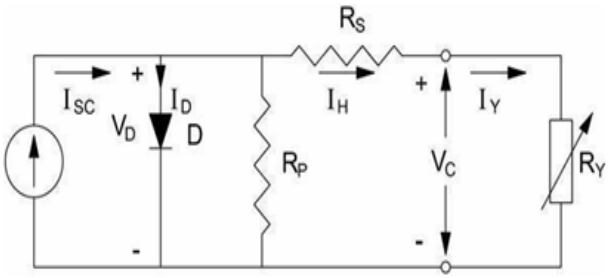


Fig 1. Equivalent Circuit of Solar Battery. [2]

A current –volt characteristic of the PV in the darkness is similar to that of the diode. Under beam, electron flow and current occur. In a closed-loop, PV current passes through the external load. Solar batteries can be represented with an equivalent circuit of a current source, a resistor, and Solar batteries can be represented with an equivalent circuit of a current source, a resistor and a diode in parallel, and an external load-resistor, as seen in Figure 1.

It is possible to incorporate an AC-DC converter, a charger, an accumulator, an additional power source, and a controller, depending on the operational and functional parameters of the various designs in question. There are two types of solar systems that can be distinguished:Line-independent systems: These are those that are set up without the use of a power line to provide electricity. Because the current in these systems is direct current (DC) and because it must be available at all times, energy is stored in accumulators, also known as DC-batteries. It is feasible to use a DC-AC inverter in the event that the appliances demand an alternating current power supply.

## II. LITERATURE SURVEY

**Chung-Hsinz Chao et al. (2019)** presents a regulatory architecture developed to steer electric golf cart hybrid power with an extended action of 5 kW. A hybrid power system consists of a fuel cell stack, batteries, ultracapacitor banks and individual power conditioner units. The proposed strategy consisted of three levels with different frequency and duration of use to optimise the overall operation. The power demand of each energy source is determined in real-time according to the frequency distribution and the cutoff frequency defined in the dynamic capacity of the energy source. In this study, to consider the characteristics of each energy source, it is easy to find the optimal set point for them. We have acquired a functional simulation that ensures that the power is in proper battery and supercapacitor charge.

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The fuel cell requires a soft current to operate under safe operating conditions. The results also show that the control strategy can adjust the DC bus voltage with the CYCUDDS golf cart drive cycle to the load profile.

**Zahra Amjadi et al. (2019)** described the stability of the use of a switched-capacitor converter (SCC) topology with cell equalization for batteries in hybrid energy storage systems (ESS) and ultracapacitor (UC) modules. The main advantage of using SCC for energy management in electric vehicles and plug-in hybrid electric vehicles (EV/PHEV) is a simple and easy control strategy that reduces the size and cost of low electromagnetic interference (EMI) energy ESSs without transformers and inductors.

**RajarshiSaha et al. (2019)** A power management technique for use in hybrid electric vehicle (EV) systems is described in this paper. In today's world, renewable energy sources such as solar power, fuel cells, and wind power are extremely important, and one of the many application fields for these sources is hybrid electric vehicles. Because of its great efficiency and dependability, photovoltaic (PV) energy was chosen as the principal power source for electric vehicles (EVs) in the current study. However, in order to ease the problem of solar cell intermittent news, supplemental sources must be used in conjunction with PV. PV with MPPT alone will not be able to meet load demand without the assistance of a backup source, especially when the load is of a high-power requirement.

As a result, hybrid energy systems that include PV, batteries, and ultracapacitors are taken into consideration. As a backup power source, battery cells and supercapacitors are employed. A bidirectional DC-DC converter stores extra solar energy and discharges it to the load when the power is required. On the PV side, two cascade boost converters are employed in conjunction with each other. Through the use of a P & O (MPPT) controller, the primary conversion is utilized to extract the greatest power possible, while the secondary conversion is employed to establish the DC link voltage in a stable manner. When there is a load fluctuation, the results of the MATLAB simulation are observed to depict the response behavior of the PV modules under various lighting situations using the MPPT method, as well as to reflect the power coordination between the PV cell battery and the ultracapacitor.

**Zahra Amjadi et al. (2020)** A control strategy for fuel cells (FC), batteries and Ultracapacitors (UC) modules in electric vehicles (EV) and hybrid electric vehicles (HEV) is being proposed and studied in 4Quadrant (4Q) switch capacitors became (SC) Luo DC/DC bidirectional converter. The FC strategy is also one of EVs' most popular and favorite energy storage systems (ESS) due to its high efficiency and ability to use hydrogen as fuel. FC and UC modules can be combined to produce a high-speed dynamic response and high output, making them ideal for automotive applications. FC also contains a high energy density, and its weight is 8-14 times that of a lithium-ion battery (Li-ion), and the FC stack can extend the battery life of EVs and HEVs. This white paper describes a novel topology and intelligent balancing strategy proposed for EV and HEV energy storage system (ESS) applications.

**MohdShadman et al. (2018)** contains information about the most reliable electric car (EV) with an extended energy source. The most important energy source includes Solar-PV, PIN and (UC). The battery acts as an important energy source for the system connected to the electrode capacitor. It acts as an energy source in the transition time, for example, during the engine's start and breaks. PV solar cells operate in stable arrangements with an improved range of movements, thereby reducing the battery size with improved battery life and rapid reaction most of the time. There is a lack of performance if there is uneven sunlight, so the system requires energy storage devices.

Normally, this type of app valve (VRLA) lead-acid battery (VRLA) is used. However, the battery plate will be invalid due to the decline to provide a large demand for electrical current during the engine start process. Other methods to provide great needs include additional VRLA batteries and supercapacitors to build a new hybrid storage system. The battery immediately functions as a continuous power source and supercapacitor in this hybrid system. This article summarizes different methods to improve the efficiency of electric vehicles.

**Lizhou Liu et al. (2019)** Hybrid Energy Storage System & # 40; Hess & # 41; This article displays an automatic balancing based on the switch-panel Switched-Capacitor converter. The advantage of the proposed system is that ultracapacitors and winter packs can simultaneously lead to equilibrium; this recognizes the energy exchange between two types of cells. In addition, the Series-Parallel Switched-Capacitor series is proposed to achieve a high level of compensation, regardless of the number of cells or their places in Hess. Only a symmetric circuit is needed to reduce the size and costs. An experimental prototype of 2 shared lithium batteries and an ultracapacitor 4 series, which has created the test results, checks that the proposed negative adjuster can achieve the balance of ultracapacitors.

**V M Sreekala et al. (2020)** Battery-powered electric vehicles have several challenges: power density, continuity of supply, and longevity. A separate power source is connected to the battery to solve this problem. This paper proposes a battery ultracapacitor (UC) hybrid energy storage system (HESS). This combination arrangement provides better power and energy density. In this case, the UC supports both the acceleration period and the regeneration period of an electric vehicle (EV). This

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white paper describes a HESS monitoring controller with a bidirectional 3-port buck-boost converter and a brushless DC (BLDC) motor. The proposed control strategy uses a conventional proportional-integral controller (PI) and a fuzzy logic controller (FLC) to adjust the battery's power level and UC's state of charge (SOC) and evaluate them with MATLAB® simulations. Based on the simulation results, it was confirmed that the controller effectively splits the load demand of the battery and UC.

**Jianlin Wang et al. (2020)** the varying dynamic characteristics of different vehicle power sources must be taken into consideration while managing the energy of new energy vehicles. An energy management technique for fuel cell/battery/ultracapacitor hybrid energy storage systems in fuel cell electric vehicles is proposed in this research, which is real-time predictive in nature. To anticipate the future speed of the vehicle and compute future power consumption, LSTM Neural Network Speed Prediction was built. It is necessary to use the wavelet transform method to safeguard fuel cells and batteries from transients that change fast and from conditions of high peak power consumption. A rule-based technique for controlling the SOC of the power supply has been implemented.

The results of the simulation reveal that the accuracy of LSTM-based forecasts for energy management is satisfactory. Using the proposed energy management method, it is possible to successfully reduce the power frequencies of fuel cells and batteries while maintaining the state-of-charge (SOC) of the supercapacitor within a suitable range, hence maintaining vehicle performance.

**K. Nakul Narayanan et al. (2018)** provided a hybrid multiport bidirectional converter system for hybrid electric vehicles (HEVs). The proposed hybrid multiport topology consists of an IC engine coupled to an alternator with a battery bank, a supercapacitor bank and shares a common DC link. The topology provided uses a high gain converter as the DCDC converter interface. A new control strategy for the closed-loop operation of the proposed topology is also presented. Control strategies are validated in PSCAD / EMTDC using time-domain simulation. A hardware prototype was created to verify the performance of the high gain DCDC converter.

**A. A. Khan et al. (2019)** Electrical energy storage has been an important element since generating electrical energy. The only option that could be stored for a long time was another electrochemical energy storage device known as a battery. But now, the fusion of electrostatic devices and chemical elements is available for storage known as ultracapacitors (UC). Both products store electrical energy as DC. Batteries are more energy-dense, and UCs are becoming more power-dense. In the case of a smart grid, the energy generated changes according to differences in environmental conditions. A change in the supply of energy from the smart grid to the battery or from the battery to the load reduces the system's reliability. A hybrid energy storage system (HESS) can provide reliability by supplying energy to the battery and the UC load. Electric vehicles (EVs) are a new trend in the automotive sector. HES onboard EVs improve the reliability of the vehicle's energy storage system. The simulation results confirm the above statement by powering a 2kW load, including transients.

**V. Vaibhav Krishna et al. (2019)** propose hybrid energy source support for electric vehicles to completely reduce the vehicle's burden of one source supply. In general, only the battery is fully supplied during all continuous operations in an electric vehicle. The motor consumes high current during rapid acceleration/deceleration and braking conditions. Low battery SOC creates thermal stress and heat, which shortens battery life. Therefore, in this study, we proposed a supercapacitor that drives the vehicle to extend the battery's life.

The battery supports the car with high energy and supplies high power with the immediate operation of the super capacitor during sudden deceleration of the motor and braking. This will help reduce the burden on one source, and these hybrid sources will help extend the life of the source in the long run. A DCDC boost converter is a BLDC (brushless DC) in which a lithium (Li) battery, a hybrid source, and an ultracapacitor are connected to maintain a power balance between the source and, if necessary, the source is used in an electric vehicle. It can be connected to a motor). The system was developed using MATLAB / Simulink.

**Zheng Guan et al. (2019)** research on hybrid power supplies with combined batteries and ultracapacitors is a hotspot in the field of electric vehicle research. The battery has a super capacitor with high energy density and power density. Perform a detailed analysis of the operating modes of the hybrid power supply system and propose an energy management strategy based on speed and speed in order to reasonably control the two types of output power and realize a more efficient operation of the electric vehicle. Logical threshold control.

The MATLAB / SIMULINK simulation environment simulates a hybrid power supply for an electric vehicle and the proposed control strategy. The simulation results show that the supercapacitor current can accurately follow the reference current. The proposed control strategy can reasonably distribute the battery and supercapacitor outputs to meet the energy output for different power supply requirements.

**Sharon S. George et al. (2018)** This paper introduces a novel energy management system (EMS) for hybrid energy storage in electric vehicles (EVs). The use of ultracapacitors as power pulsation storage in EVs can

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reduce the inefficiencies associated with the low power dynamics of battery cells. Therefore, since lithium-ion batteries have a high energy density, EVs can supply average power. These hybrid systems lead to managing the energy between each battery and the UC cells. In addition, the EV drive powertrain should extend the maximum torque per ampere operation to account for the load conditions of the motor.

Therefore, modular multi-converters are configured to manage energy between different storage cells for EV applications. And with MMC, you don't need a system-level drive or inverter to power your EV motor. The results are presented to validate the efficiency of the proposed configuration.

**M. Zeeshan Tariq et al. (2021)** In response to the global contribution of renewable energy storage systems (RES), we have noticed an undeniable surge in marine electrical systems. On the other hand, to address the intermittent RES. A battery energy storage system is built into the system. However, the problem is that the energy density is low and the lifespan is short, which increases the space required and increases the cost. To solve this problem, it is recommended to equip an ultra-capacitor battery energy storage device. Therefore, the integrated system provides greater dynamic performance using relatively less space and higher energy.

In order to take advantage of these advantages in this integrated system, it is necessary to realize the optimal management of power generation and consumption. This requires the development of accurate and robust control algorithms. This paper proposes an effective control technique in which a PV-powered hybrid energy storage system (HESS) integrates with a conventional diesel generator to supply power to marine loads, primarily lighting and heating. In addition, various possible operating modes for realizing optimal performance given the inconsistency of PV generation are described and verified using simulation results. Meanwhile, some of the major contributions of the proposed control scheme are maximum power extraction from PV panels, power factor single operation of the utility grid and improved reliability of connected loads.

**Kai Han et al. (2019)** a new energy distribution strategy (EMS) based on power management rules and model predictive control (MPC), is being proposed to optimally distribute power between lithium batteries and ultracapacitors in hybrid electric vehicles (HEVs). The proposed EMS has large requested power, and the MPC strategy is applied if there is enough energy in the battery ultracapacitor. Otherwise, a rule-based strategy is adopted. The future speed is predicted using the MPC strategy, and a sequential quadratic programming algorithm solves the nonlinear MPC output calculated by the required power. The performance of the proposed strategy is tested on the HEV experimental platform by three typical driving cycles (ECE cycle, UDDS cycle, HWFET cycle and its hybrid cycle). Experiments show that the proposed strategy helps save power more efficiently than the rule-based strategy.

**Chen Zhao et al. (2020)**As part of a battery's supercapacitor hybrid energy storage system (UC), this study examines equivalent series resistance (ESR) based controls, or circuits, that efficiently disperse the load (HESS). We advocate for a level playing field. The first step is to develop an exemplary capacitor semi-active HESS ESR circuit model in order to demonstrate energy loss at both the circuit and system levels. It has been determined that the overall energy loss of HESS is solely dependent on the percentage of total dynamic load given by the battery pack, as determined by the analytical results. Depending on the load distribution indicated by the percentage of the battery pack's ESR in the total ESR of the UC pack as well as the total ESR of the dc-dc converter, this energy loss can be avoided.

Following that, we create an ESR-based real-time control technique to reduce energy loss while also adjusting the UC state of charge (SOC) to prevent overcharge and overdischarge of the battery. As a result of the suggested ESR-based control, both simulation and experimental findings demonstrate that it is effective in improving energy efficiency, enabling the use of UC packs, and decreasing the temperature rise of the battery. When used in conjunction with ESR-based control, performance is very similar to that of optimal dynamic programming. Under control based on the suggested ESR, the total energy loss and battery temperature rise of the HESS example are decreased on average by 44.9 percent and 51.9 percent, respectively, when compared to the battery-only system.

**Bin Wang et al. (2020)** Using the real-time average power approach, we devised a multiplication method to increase the output mode switching frequency of a multi-mode hybrid energy storage system (HESS) battery for electric vehicles. In order to achieve multi-mode HESS mode conversion and distribution, a rule-based method is developed in accordance with the high-frequency power requirement. It also makes use of a straightforward real-time average power approach to deal with high-frequency power requirements.

The following real-time average power is utilised as a variable logic threshold for the power split technique, and it is calculated as follows: Multimode HESS high-frequency mode switching can be avoided by using power split controllers, which switch to smooth average power rather than high-frequency power demand. The ultracapacitor serves as a reinforced low-pass power filter, and the battery is capable of providing a smooth and reliable output to the motor inverter when used in conjunction with it. It is necessary to run a comparative

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simulation between the developed power split approach and the rule-based method. In the next three typical driving cycles, the advantages of the power split method that was created to boost battery output as well as electric vehicle multi-mode HESS mode switching frequency are demonstrated. Furthermore, because the real-time average power duration is designed to be longer, the battery's output is more smoothly distributed, and the multi-mode HESS mode switching frequency is reduced, the battery's output is more consistently distributed.

**Krishna Chaithanya et al. (2020)** The rapid growth of renewable energy integration in existing power system networks poses a serious threat to system inertia, replacing synchronous generators with null inertia power electronic converters connecting renewable energy to the power system. Do. To overcome this, connected power electronic converters (ILCs) act as synchronous generators that synthesize virtual inertia. This paper proposes a distributed virtual inertial control scheme in which a hybrid energy storage system (HESS) and ILC of a hybrid ACDC Microgrid act cumulatively as synchronous generators.

The proposed control method operates as a rotor mass using a high-power density storage device such as an ultra-capacitor integrated on the DC side, synthesizes the virtual inertia required by the power system, and connects the outside, the book and the community using the battery as a virtual governor. It compensates for the lack of power in the steady-state during operation mode. The proposed control scheme is verified through the loop simulation power hardware of the hardware prototype.

## III. HYBRID ENERGY STORAGE SYSTEMS

Hybrid energy storage systems (HESS) are designed to improve the efficiency of energy management in electric cars. These solutions make use of various energy and power sources in order to take advantage of their respective properties to the greatest extent possible, allowing for a reduction in the size, efficiency, and cost of the embedded source.

One of the most significant advantages of this unique strategy is that it improves the thermal battery behaviour, which is one of its most significant advantages. As a result of this advancement, it is possible to realise significant cost savings while also improving the performance of electric vehicles. The hybrid embedded power supply with EMS3 has a lower weight over the whole vehicle operating range than the conventional embedded power supply. For all of the configurations under consideration, we may distinguish between two major periods of weight evolution.

There are two types of situations: first, when the weight remains constant throughout the vehicles operating range, and second when the weight grows fast during the vehicle's working range. Thus, the first phase of the hybrid embedded power supply is scaled under the discharge power limitation, which is constant and more stringent than the energy and charge constraints.

However, during the second phase, the energy constraint is greatly influenced by the operating range of the vehicle. As a result, the final size of the hybrid embedded power supply is dictated by the energy consumption constraint mentioned above. For each of the proposed configurations, the RMS power stress was given to a single battery cell. This test enables us to establish a preliminary evaluation of the battery's ageing. According to our assumptions, the battery management system (BMS) is responsible for preventing the uneven cell voltage in a series-connected battery pack. Therefore, it is considered that the BMS is solely responsible for the maintenance of voltage balance during both the charging and discharging phases of the battery's life cycle.

Because of the significant RMS power stress experienced during the first phase of constant weight when the discharge power constraint is more stringent than other phases, the hybrid power supply with EMS3 has been demonstrated to be effective. Because of these advantages over the single HP battery design, this approach became significantly more appealing for vehicles with large values of vehicle operating range after that. The hybrid integrated power supply with EMS1 and EMS2 provides low RMS power stress over the entire working range of the vehicle's electrical system. This is due to the fact that the battery pack contains a significant number of cells.

## IV. CONCLUSION

When paired with batteries in a hybrid energy storage system, ultra capacitors provide advantages over traditional batteries. Energy efficiency savings, also known as charge efficiency, are the primary benefit of this inquiry, and it will be the emphasis of this investigation. Charging efficiency was determined by determining how much energy was given to a load for each unit of charge supplied by the battery. When it comes to this inquiry, the hybrid energy storage system (ESS) is of the most basic type: it simply shunts the ultracapacitors over the battery without any power electronics in between.

The complementary qualities of these two devices - batteries with high energy density and ultracapacitors with high power density - functioning together could improve the performance of certain systems that rely on only one of them alone. The majority of systems that profit from this have low average power but extremely high peak power. The increase in efficiency in hybrid energy storage systems is directly related to the increase in battery lifetime despite the fact that this theory does not quantify the increase in battery lifetime]. This thesis will be

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concerned with estimating the energy efficiency boost obtained by varying the variables of pulse amplitude and duty cycle in real time.

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