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INVESTIGATION ON ENERGY MANAGEMENT SYSTEM OF HYBRID ENERGY STORAGE SYSTEM IN ELECTRIC VEHICLES

Kokilavani Thangaraj, Department of Electrical and Electronics Engineering, Sona College of Technology (Autonomous), Salem, 636005, Tamil Nadu, India. kokime.t@gmail.com
Kannan Kandavelu, Department of Electrical and Electronics Engineering, Annapoorana Engineering College (Autonomous), Seeragapadi, Salem, 636308, Tamil Nadu, India.
Anbuchezian Ashokan, Department of Civil Engineering, Annapoorana Engineering College (Autonomous), Seeragapadi, Salem, 636308, Tamil Nadu, India.
Silambarasan Rajendran Department of Mechanical Engineering, Annapoorana Engineering College (Autonomous), Seeragapadi, Salem, 636308, Tamil Nadu, India.

Abstract

Initially, the instantaneous minimisation of the comprehensive cost was considered the objective function. Third, it was demonstrated that the HIOC-EMS was a reliable and effective technique for enhancing the HESSs' energy management system. The reductions in battery losses of 20.14%, 12.47%, and 19.27% as well as comprehensive cost reductions of 10.26%, 5.42%, and 10.23% over the course of three distinct driving cycles, according to the experimental results. Additionally, the HIOC-EMS led to higher comprehensive costs of 7.43%, 3.27%, and 2.04%, and higher battery losses of 15.32%, 11.26%, and 5.47%, respectively, in comparison to the dynamic programming EMS. These outcomes demonstrated how well the HIOC-EMS worked to lower the cost of using electric cars with HESSs.

Keywords:
energy management strategy, hybrid energy storage systems, hierarchical instantaneous optimal control, electric vehicles

Introduction

Electric vehicles (EVs) are more economical and ecologically beneficial due to their low energy usage and straightforward power system architecture. EVs have become the unavoidable alternative for people looking for a cleaner and greener mode of transportation as the globe moves towards a more sustainable future. Power battery performance will deteriorate, life cycles will be shortened, and EV usage costs will rise [1]. Super capacitors' low specific energy is a disadvantage, despite its advantages. They are therefore unsuitable for use as EVs' exclusive power source [2]. Supercapacitors and power batteries are used in hybrid energy storage systems (HESSs) for EV to overcome this restriction. HESSs capitalise on the advantages of both parts. They also effectively absorb the kinetic energy.

By making sure that electricity is distributed in a way that optimises performance overall, this strategy aids in boosting the system's efficacy and cost efficiency [3]. The cost of power batteries makes up a significant amount of the total cost of a vehicle, and their ageing process intensifies as operational duration increases. Rule-based and optimization-based EMSs are now the two most popular varieties. While optimization-based EMSs make use of convex optimisation techniques, genetic algorithms [4]. Investigated EVs with HESSs and, after taking into account, power batteries, and supercapacitors, developed a logic threshold control technique. These results suggest that the strategy can improve car performance and reduce the battery's maximum power requirement. While preventing high currents during charging and discharging [5-6].The best discharge power was found using fuzzy rules, which decreased battery current variation. In order to attain maximise battery life and lower the cost of [7]. They have optimised the evolutionary algorithm Additionally, [8]. EMS based on convex optimisation to circumvent issues with dynamic programming's high computational burden and search algorithms' suboptimal results. In conclusion, the fuzzy control strategy's control rules are based on professional knowledge and merely call for basic algorithms. However, the globally optimal outcome and the method's optimisation effect differ significantly, and the strategy is subjective. Although dynamic programming can yield the best solution to an issue, its high computation time makes it unsuitable for real-time applications. Prior to application, convex optimisation requires convex processing, which is challenging to execute. One common instantaneous optimisation approach that offers real-time benefits and is very useful in applications is instantaneous optimisation control (IOC) [9]. As a result, the algorithm is becoming more and more popular in industrial control A unique EMS with strong real-time optimisation effects was created using the previously outlined methodology.

EV power train configuration

The schematic diagram of the EV power train structure is shown in Figure 1. Its primary parts are a drive motor, a supercapacitor pack, and a ternary lithium battery pack. The EV model's HESS structure is semi-active, consisting of a bus made up of the motor controller, BMS, EMS, and power battery connected in series. Initially connected in series. With this HESS setup, the supercapacitor may provide a power battery can meet the vehicle's range requirements.

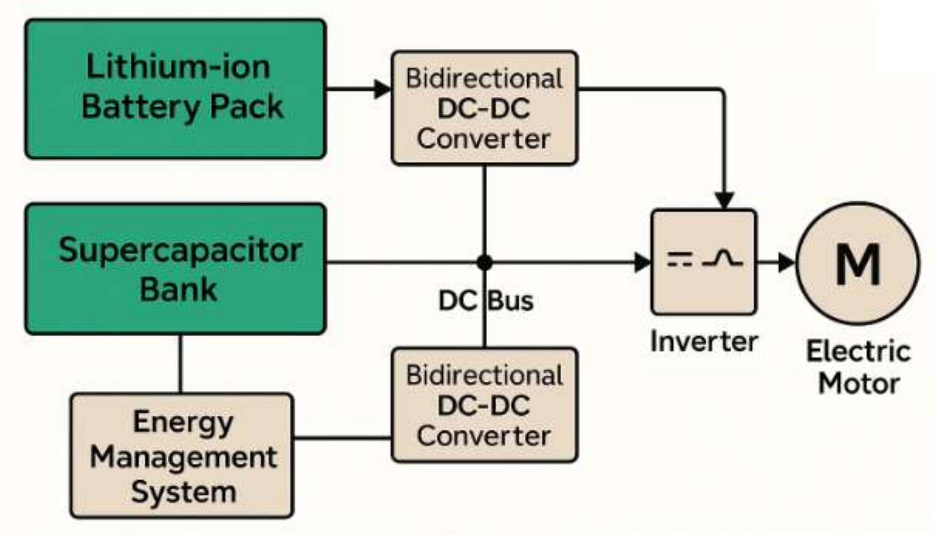

Figure 1 EV power system structure

HESSs come in a variety of forms. A supercapacitor connected in parallel with a battery pack is depicted in Figure 1. It is a feature of this design that provides benefits including low cost, easy management, and streamlined construction. A system is put in place to control the structure's energy flow by keeping an eye on variables including power usage, battery state of charge (SOCb), and supercapacitor state of charge (SOCu). This makes it possible to calculate the power produced by the power battery and supercapacitor [10]. **Performance validation of the HIOCbased energy management strategy**

The simulation results are shown in Figure 2. The power distribution link between the HIOC algorithm's power battery and supercapacitor is seen in Figure 2A. As seen in Figure 2B, the rise in Cbr outweighs the fall in Ce. At points 1 and 2 in Figure 2A, lowering the cost of electricity use without affecting the cost of battery ageing and at any given time is determined by the current energy price and the cost of buying the battery pack, as illustrated in Figure 2A. The supercapacitor fully absorbs the feedback power under the parameters described in this article. Figure 2C illustrates study of the HIOC-EMS's adaptability and optimum-searching capability is necessary to assess its performance even further [11-13].

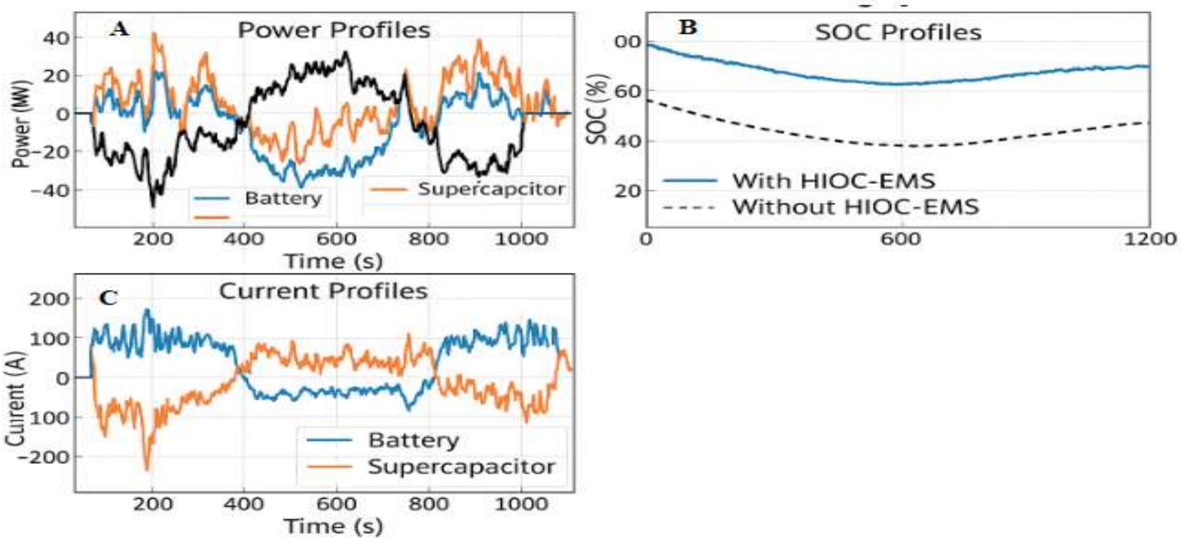

FIGURE2

Analysis of the simulation results

Four factors the supercapacitor state of charge (SOC), energy consumption, battery loss, and total cost were chosen as evaluation of various energy management techniques. Furthermore, considering that the roadways used for EV travel include city ring motorways, rapid arterial roads, and urban roads, three standard driving cycles were chosen. Figure 3 shows the global optimal method, DP-EMS, has a different NEDC and WLTC cycles, the supercapacitor SOC of the HIOC-EMS is greater than the beginning SOC.

As a result, it can complete a rotating cycle. At the conclusion of the three driving cycles, the HIOC approach uses a little more cycle energy than the other two, as seen in Figure 4. The algorithm prioritises using the supercapacitor in operation. Additionally, the supercapacitor raises the cycle energy consumption, which is influenced by the DC-DC voltage rise efficiency. Battery loss is decreased in the HIOC-EMS [14]. Figure 5 illustrates how the power battery loss percentage sharply declines. The HIOC-EMS has a smaller battery loss than the other two techniques when the supercapacitor power is adequate. Additionally, the HIOC-EMS's power battery loss at the conclusion of the cycles is comparable. The total expenses of the three techniques in the three driving cycles are contrasted in Figure 6. As demonstrated, the HIOC-EMS's overall cost is comparable to and noticeably superior to that of the PFZY-EMS [15]. The HIOC-EMS suggested in this paper reduced were in comparison to the DP-EMS. According to the previously reported findings, the HIOC-EMS performed noticeably better than the PFZYEMS and marginally worse than the DP-EMS. The impressive gains made by the HIOC-EMS confirm that it is a very effective EMS [16–17].

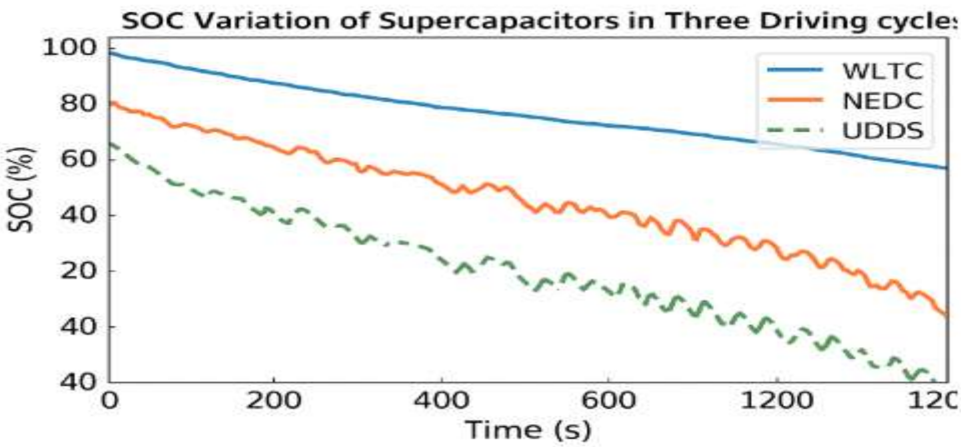

FIGURE3 SOC variation of supercapacitors in three driving cycles

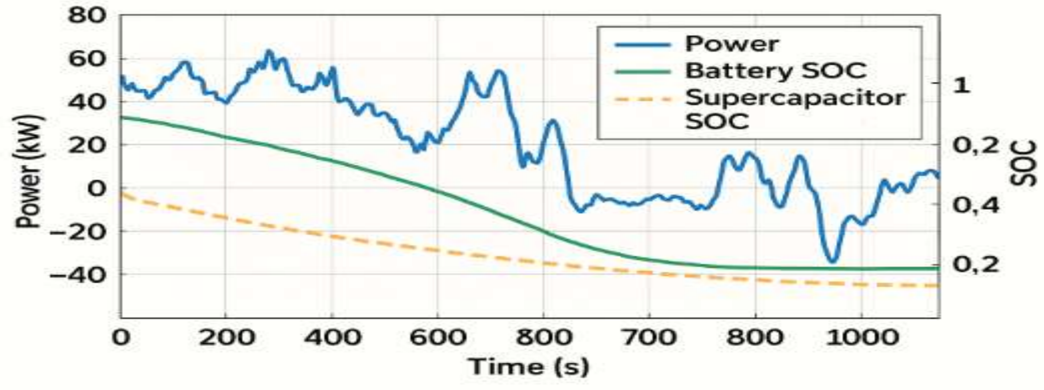

FIGURE 4 Energy consumption in three driving cycles

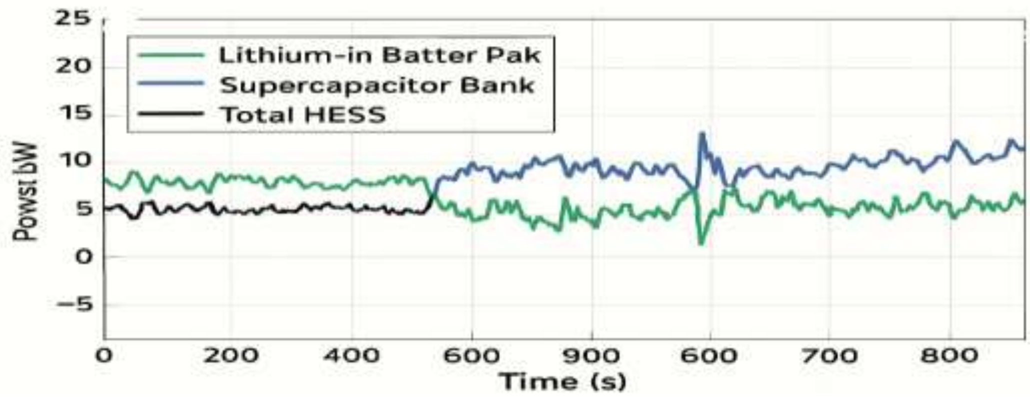

FIGURE 5 Curves of the battery loss percentage in three driving cycles

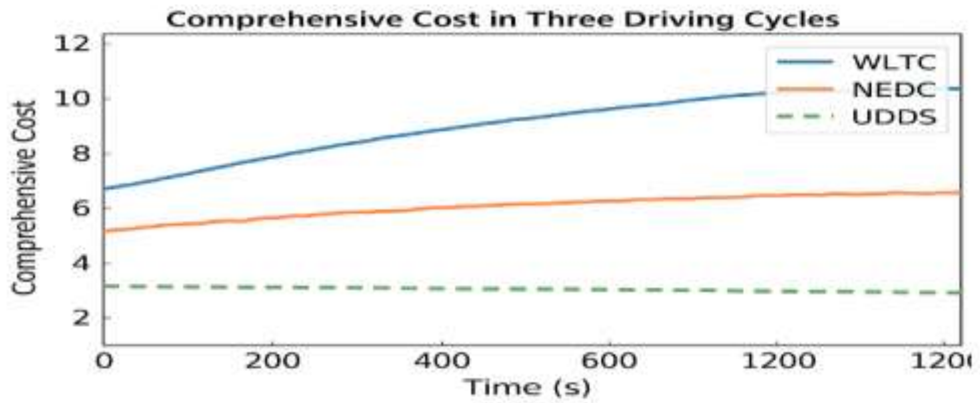

FIGURE13 Comprehensive cost in three driving cycles

Conclusion

In this study EV operation with HESSs made of batteries and supercapacitors was examined. To lower the overall cost, which took into consideration the cost of power battery ageing as well as the cost of electricity usage, a hierarchical was suggested. The DP-EMS and the PFZY-EMS were contrasted with the suggested HIOC-EMS. The following are the main conclusions drawn:

1) The optimisation goal was to minimise HIOC technique with a logic layer and an optimisation layer, the supercapacitor's ideal coupling coefficient was determined. For EVs with HESSs, the HIOC was subsequently implemented.

2) MATLAB and Simulink tools were used for simulation and verification. The findings shown that, at the expense of minimal energy expenses, the HIOCEMS dramatically decreased and demonstrating impressive optimisation effects.

3) The EMS created in this research hasn't been tested on real cars yet.

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