Original Article

Advancement of a Hybrid Energy Storage Framework (HESS) For Electric and Plug-in Hybrid Electric Vehicles: A Modern Control Technique

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Abstract

Hybrid systems (HEVs) are becoming more popular in transportation systems to reduce energy use. Due to their environmentally benign performance and contribution to the smart grid concept, HEVs are gaining a lot of traction. HEV types vary due to the variety of energy storage technologies (such as rechargeable, capacitors or ultracapacitors, hydrogen fuel, and so on) and control methodologies. This article included information on energy storage technologies for Electric vehicles (EVs and the production of various types of improvement schemes depending on multiple control strategies and plug-in hybrids was included in this article. The study categorizes distinct control mechanisms grounded on three configuration options energy cell, battery, and ultra-capacitor. To demonstrate the benefits and downsides of colorful control ways, several control ways are carried out grounded on control aspects and operating conditions. For distinctive mutt arrangements, a parametric comparison and cross-comparison are advertised to show a relative investigation grounded on channel smoothness, battery continuation, vitality viability, vitality utilization, displacement, versatility, and so on. The investigation to analyzes the investigation stage, the upgrade of driving cycles, and fine models of each control technique in arrange to illustrate the fashion's trustability in genuine-world operations. Researchers, policymakers, and innovators who constantly develop HEVs with energy-efficient control systems will find the offered recapitulation reliable.

Keywords: EV, Battery, Fuel Cell, Ultracapacitor, Hybrid System, Matlab, Simulink Model.

I. INTRODUCTION

The world is progressing toward an era with more facilities that are updated with new inventions; pollution levels are rising at the same time, causing constant harm to all living things. Conventional automobiles with a diesel machine (ICE) contribute significantly to this problem, performing in a significant hothouse effect (1). Thus, the thought of electric vehicles (EVs) came up with diverse vitality storage facility inclination compared to batteries, supercapacitors (SCs) or ultracapacitors (UCS), and vitality cells (FCs) (2). Amendment over these EVs made mutt electric vehicles (HEVs) as a combination of the once specified sources with expanded adequacy and adequate help in icing proceeded control drive in vehicles. Veritably intellectuals, the displacement rate of CO2 and CO can get reduced by the legitimate establishment of HEVs. Battery life can be effectively amplified up to a palatable position; FC's life can presently be planted in a less demanding standard (3). Experimenters have utilized distinctive control procedures to deliver genuinely- time operation over a long-separate (4). By tending to streak cargo conditions, the utilization of UCs as a new source of power in any framework makes a difference to palliate battery or FC stretch. The whole preparation is controlled by keeping up the state of charges (SOC) position for the isolated sources fitted, taking into consideration any changed topology, or as a fashion to oversee transformers within the framework. In later times, control methodologies comparable as commensurable-integral- outgrowth (PI) controller (5), fluffy control (FLC) (6), line shadowing oversee (Demonstrate prophetic control) (7), rule-grounded control (8, adaptive filtering regulation (9), dimensional system operation (10), authentic performance- grounded control (11), and numerous others have been proposed. More study into the improvement of HEVs is underway. By incorporating a plug-in rechargeable battery, crossbreed electric vehicles (PHEVs rechargeable batteries (PHEVs) increment battery capacity. 1,2 Combined vehicle components control is required by PHEVs. 2 As a result, in PHEVs, a vitality administration methodology (EMS) is required to preserve the working conditions of the diesel motor (ICE) as well as the battery. PHEVs are classed as consecutive PHEVs, parallel PHEVs, or series-parallel PHEVs based on the distinctive association topologies between both the Motor, the capacity, and the engine controller (EM). Adaptable working strategies in set PHEVs can deliver lower outflows and more noteworthy driving execution than arrangement or parallel PHEVs. An EMS for series-parallel PHEVs that's well-designed decreases outflows whereas upgrading fuel economy (FE). The objective of the EMS technique is to get the least complexity whereas keeping up tall efficiency.

Energy efficiency refers to providing the very same operations with less energy usage, as well as employing sustainable and environmentally friendly energy to do so. Energy efficiency is essential for port facilities that want to cut energy use (and thus emissions) and become more environmentally friendly. Technological advancements in energy production, storage, distribution, conversion, and consumption have a significant impact on energy efficiency. Batteries, distributors, and converters are all part of the energy systems used by ports. Energy efficiency can be improved further as new ways for improving grid intelligence emerge, and new devices engineered to economically store energy (e.g., flywheels, supercapacitors) are developed. In a fact, port equipment with power management components can save a lot of energy by conserving it when hoisting down, storing it, and then using it for hoisting up or traveling motions. Sophisticated power distribution systems can improve energy efficiency in the refrigerated area. Technological advancements also help to reduce fuel use. As a new fuel-saving technology, As renewable sources become more prevalent, technological advancements in harvesting alternative sources are also significant for ports.

Main objectives

- The classification of the selected control methods in terms of respective source configuration is a noteworthy contribution to the research work.
- The adaptive neuro-fuzzy is employed to regulate the entire system in this case.
- The management system is a critical component for controlling all of the system's components and circuits. The fundamental purpose of a control system is to regulate the voltage or current flow in each of the system's blocks. The classification is then broken down into several terms based on the methodology used.
- The primary goal was to create a model based on a hybrid energy system. The Matlab R2021a software was used to design the model.
- We can use three sources to drive the vehicle depending on the Energy Storage System: ultracapacitor, battery, and fuel cell.
- Finally, the experimental findings are displayed inside the system's scope.

The remainder of the paper is divided into sections. Section I outlines the system's Introduction section, Section II the Literature Review section, Section III the Problem Statement section, Section IV the Methodology section, Section V the Analysis and Discussion section, and Section VI the Conclusion section.

II. LITERATURE REVIEW

Andari, W et al describe the " A PEM hydrogen energy hybrid vehicle's design, modeling, and energy management ". The goal of this research is to investigate and model a combination Proton-conducting Membrane (PEM) Energy Storage electric vehicle. In actuality, the study is about the powertrain concept, which incorporates two sources of energy a Membrane (pem) energy Cell as the major source and capacitors as the secondary source. The armature has two degrees of freedom, allowing the DC machine voltage to be stable. The combination of the main source and an energy storehouse device can enhance vehicle dynamic response and hydrogen operation during transients. The grounded energy operation algorithm enables us to consume the least quantum of hydrogen possible. The boscage energy recovery fashion is grounded on lithium battery state of charging (SOC) operation and acceleration/ retardation phases. Using Matlab/Simulink software, the suggested model is simulated and verified, allowing for quick transitions between sources.[12]

Kraa, O., Ghodbane, H., et al., "Vitality administration of fuel cell/supercapacitor cross breed source based on direct and sliding mode control". This work portrays the demonstration and control techniques for a hydrogen and fuel cell/supercapacitor source utilizing Pid and stochastic sliding mode controllers. To supply the stack requests within the unfaltering and transitory states, it is made up of a Regenerative Fuel Battery (Fuel cell framework 500 W) and an electrochemical capacitors stack (800 W) both primary and assistant sources, separately. To oversee DC transport voltage and find out the FC's reference current, a conventional PI controller was altered. Sliding mode controllers have been used to oversee the SC and FC streams utilizing boosting and Converter bidirectional converters, individually, due to their quick response within the transitory state and their capacity to work with a consistent or changing frequency. The recreation comes about in Matlab/Simulink illustrated that the show control methods effectively overseen and controlled the crossover framework whereas to assembly the control request with unfaltering and strong performance.[13]

A. Wahib, G. Samir, A. et al., ``Energy administration methodology of a fuel cell electric vehicle: Plan and implementation,''. The objective of this work is to make a control administration boss for controlling the stream of control in a hydrogen fuel cell car with a crossover vitality capacity framework and a supercapacitor. The goal of this work is to reduce the hydrogen expenditure of a Porous Membrane (PEM) FuelCell. To do this, the system is regulated using an Energy Management System (EMS), which reduces the power demand transitions of the fuel cell and so improves its longevity. MATLAB software was used to create the model of the researched parts of the system and the control strategy. Simulation results of our suggested method show a 40% reduction in hydrogen consumption due to recaptured electricity from braking phases. [14]

Gnanavel, C., Muruganantham, et al., "Test Approval and Integration of Solar oriented PV Encouraged Measured Multilevel Inverter (MMI) and Flywheel Capacity Framework". This article depicts how to utilize a multilevel inverter to develop a solid vitality effectively for sun-powered photovoltaic (SPV) establishments (MLI). The objective of the venture is to plan and develop an eleven-level inverter as well as a Field Vitality Capacity Gadget (FESS), both of which can be employed in a naval environment. In the absence of a filter, the main purpose of the design is to enhance inverter control performance and reduce Total Harmonic Distortion (THD). After unplugging the maximum demand, the AC energy is supplied and sent through into the driving motor system. The free energy concept of energy generation is presently figured out by recovering control from turning and exchanging it once more for ceaseless operation. The Control scheme was employed to obtain the best THD results. Finally, this study examines the types of controllers that are needed to produce dependable and effective THD results. After unplugging the maximum demand, the AC energy is transformed and sent directly into the driving motor system. The Control scheme was employed to obtain the best THD results. Finally, this study examines the types of controllers that are needed to produce dependable and economical THD results.[15]

III. PROBLEM STATEMENT

The paper uses the technologies of ESSs, their classifications, features, construction, electrical conversion, and evaluation methods with benefits and drawbacks for EV applications in our existing system. Furthermore, this study analyses numerous categories of ESS based on their energy forms, composition materials, and strategies on average energy delivery overcapacity, as well as overall efficiency displayed throughout their life expectancies. Although existing ESS technologies can be employed for EVs, the optimal usage of ESSs for effective EV energy storage devices has yet to be reached, according to comprehensive research. Finally, the load will be driven only by the battery system. If the battery is dead, you won't be able to operate the load.

IV. METHODOLOGY

To implement the Integrated Energy infrastructure for EV Applications, we propose the following way. To regulate the program or data held on the system's Battery and Fuel Cell models. A charge and hydrogen fuel model are connected in parallel via a DC-DC Converter to hold the DC Bus produced in the Dc/dc converter section to operate the motors for Electrical vehicles. To monitor the current rate of the batteries and fuel cell; if the actual level drops at that time, which type of power generation will be documented and sent to operate the load. If the battery is dead, we'll use the boost converter to keep the load running. As a result, this disadvantage will be eliminated by utilizing the two sources to efficiently operate the load.

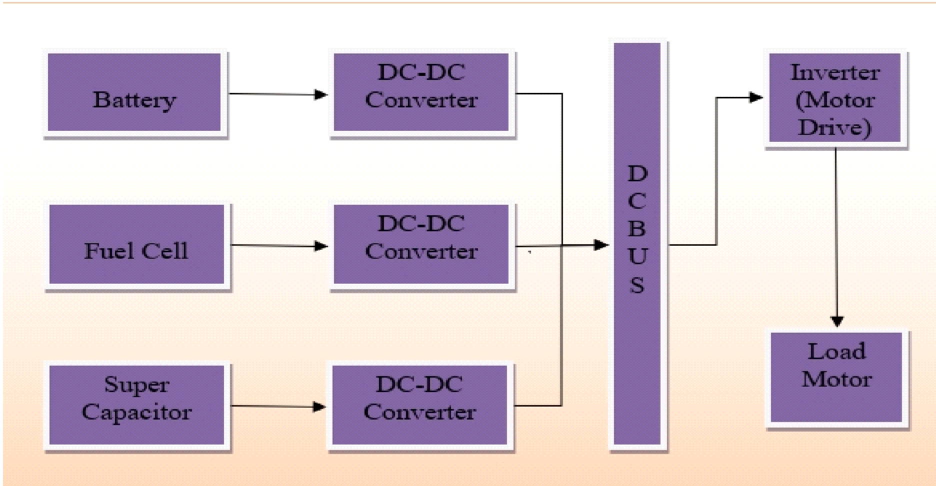

Figure 1 Block Diagram of our Proposed method

On the input side, we can use three sources: battery, fuel cell, and supercapacitor; on the output side, we can just use the Dc-Dc boost converter, DC bus link, and inverting motor control drive; and on the load side, we can use the system's motor.

IMPORTANT BLOCK IN OUR SYSTEM

- Battery
- Fuel cell
- Supercapacitor
- Dc-Dc Converter
- Inverter Control Drive
- Control Section
- Motor

Battery: A battery could be a gadget that employments an electrochemical decrease (redox) cycle to change over chemical vitality put away in its dynamic components straightforwardly into electric vitality. Electrons are exchanged from one component to another on the electric circuit in this type of response. An electric battery could be a control source made up of one or much more electrochemical responses with outside associations that can be utilized to control electrical hardware. The positive terminal of a battery is the cathode, and the negative cathode is the anode when it is providing electric power.

Fuel Cell: A fuel cell is an electrochemical cell that employments a combination of redox forms to convert the chemical vitality to electrical vitality (ordinarily hydrogen) and an oxidizing operator (common oxygen) into power. As long as fills and oxygen are accessible, fuel cells can make control inconclusively. Transportation, fabric dealing with, and changeless, transportable, and fundamental backup power are fair a couple of of the applications for fuel cells.

Super-capacitor: Supercapacitors are high-capacity capacitors in a nutshell. They have a higher capacity and lower voltage restrictions than other capacitor types, and they function similarly to electrochemical capacitors and battery packs. Supercapacitors have a lower energy density than lithium-ion batteries, which are often used in phones and laptops nowadays. Supercapacitors can completely replace batteries in hybrid buses for this purpose, while all-electric bus services require fewer batteries. In autos, buses, trains, cranes, and elevators, supercapacitors are employed for rechargeable batteries, simple energy storage, or packet power delivery, but instead of long-term compact energy storage.

DC-DC Converter: Power converters are high-energy conversion circuits that smoothed out switching losses into regulated Voltage levels using slightly elevated switches and passive components, transformers, and capacitors. Even when the input signals and output currents change, circular feedback loops maintain a consistent voltage output. For various appliances, DC-to-DC converter topologies are used to convert high voltage Power input to lower voltage output.

Inverter Control Drive: AC Drives, or VFDs, are other names for inverters (variable frequency drives). They are electronics that can convert DC (Current (dc) to Ac (Alternating Current). It is also in charge of regulating the speed and torque of electric motors. Electricity is required to drive these motors. This capability is utilized by an inverter to oversee the torque and speed of an engine. The inverter creates a beat voltage, which is smoothed down by the engine coil, coming about in a sinusoidal waveform current that controls the motor's speed and torque. The inverter produces a pulsed voltage output.

Control Section: In the control section part, we can use the ANFIS controller of the system. The proposed approach could be a basic information learning strategy that utilizes Fluffy Rationale to change over given inputs into craved yields using exceedingly coordinates Neural Organize preparing units and data associations that are weighted to decipher numerical inputs into yields. In a single framework, the Versatile Neuro-Fuzzy Processing Element (Adaptive neuro-fuzzy inference) combines the benefits both for Artificial Neural Network (ann (ANNs) as well as Fuzzy Logic (FL). It has a high rate of learning and adaptive interpretation capabilities, allowing it to model complex patterns and understand nonlinear relationships.

Load: We can employ the system's motor in the load section. Typically, a motor refers to any device that uses energy to generate motion in a system.

V. ANALYSIS AND DISCUSSION OF OUR PROPOSED METHOD

We can show the circuit of our proposed framework method in the analysis and discussion section.

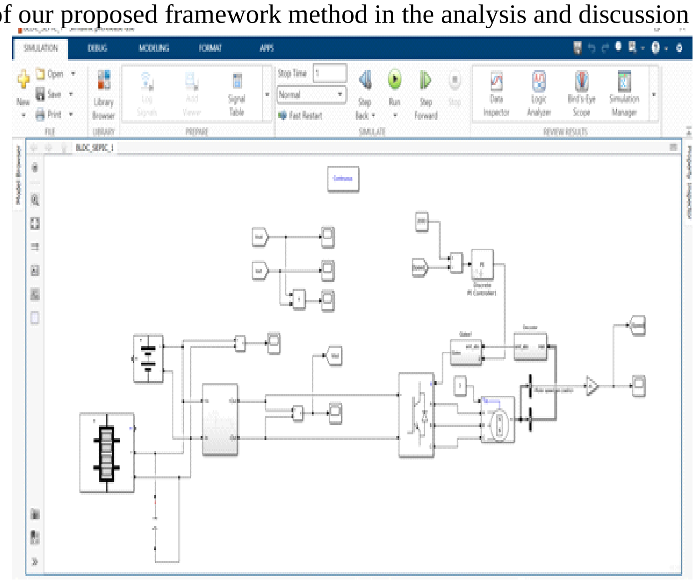

Figure 2 Circuit Diagram of our Proposed method

This diagram depicts several blocks that are used to display the outcomes when three sources of input are used. Batteries, ultracapacitors, and fuel cells are the three types. Following that, the inverter and controller parts are adaptive neuro-fuzzy, and the motor plays a role in our system's load.

OUTPUT RESULTS

The scope of our proposed method's output results is Input Voltage from three main sources, Output Voltage, and Rotational speed connected to the system's load side.

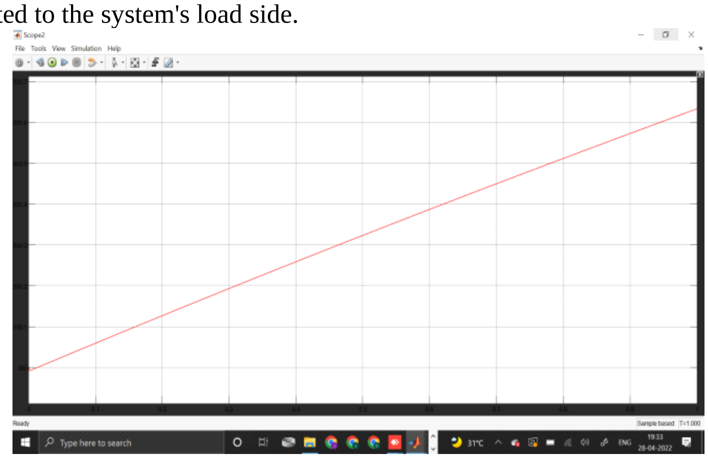

Figure 3 Voltage of the system

(Steady voltage output from one of the primary sources of the three sources that are required to run the load, which is obtained from the scope connected to the subsystem)

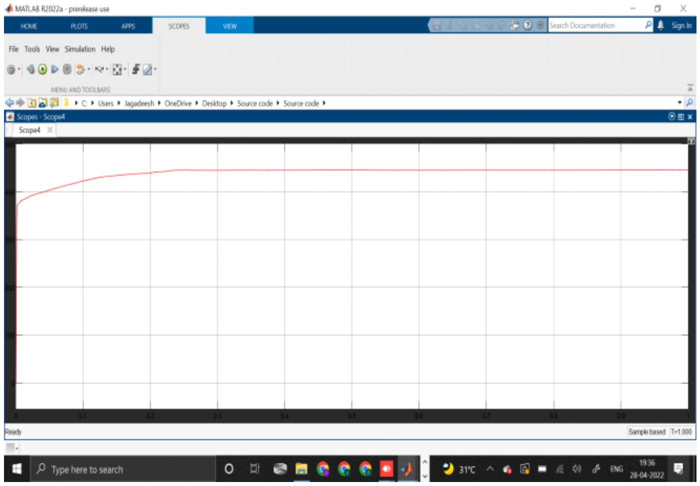

Figure 4 Scope of Output Current of the system
(Output current that is obtained for the same that is to run the bldc motor)

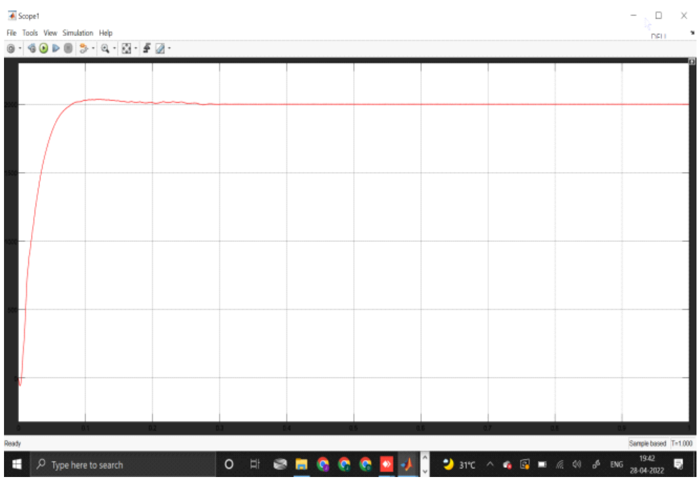

Figure 5 Speed of the motor
(Speed at which the BLDC motor is running, the unit of measure is RPM and the test run rpm is 2000 and it is observed that it is holding that perfectly)

CONCLUSION

This work presents a thorough analysis of several HEV control systems for three different energy sources: battery, fuel cell, and ultracapacitor. The research compares several control systems for different settings based on objectives, control features, operating situations, fuel consumption and production, energetic reactions, battery lifespan, and other factors. For battery-UC arrangement, the relative analysis reveals that the Adaptive fuzzy inference system-based EMS is more productive and adaptable than others. On the three sources, a rule-based algorithm is demonstrated to operate the system and generate the system's input voltage. According to the findings, the creation of electric vehicle charging facilities, as well as the potential of sharing charges between two HEVs, may well be a promising region for future inquiries. The importance of improving the operating life cycle in HEV operations can't be exaggerated in arrange to hold ideal performance. Finally, the proposed solution improves the system's performance, stability, adaptability, and efficiency.

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