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Comparative Assessment Of Hev Systems Using Advanced Optimization Strategies

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ABSTRACT

Hybrid Electric Vehicles (HEVs) are pivotal in reducing greenhouse gas emissions and mitigating the reliance on fossil fuels. The design and operation of HEVs involve complex systems requiring careful optimization to achieve a balance between performance, fuel efficiency, and environmental impact. Optimization methods such as hybrid heuristic approaches (HYSGFA and Particle Swarm Optimization), analyzed in this manuscript. These techniques are applied to improve energy management, improving the state of charge of BMS. The comparative study highlights the difference between PID, FOPID Controller for enhancement of state of charge of battery using Optimization Techniques. The Proposed Hybrid Optimization Technique improves the performance of Hybrid EV System and enhances improved response in terms of various performance indices.

Keywords—*RES, EV, PID and FOPID, SOC, HYSGFA*

1. INTRODUCTION

Numerous research studies have explored electric vehicle (EV) charging systems utilizing two alternative power sources: photovoltaic (PV) systems and single-phase grid power. This paper presents an EV charger designed to operate in both Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) modes. A comprehensive mathematical model for the entire charging system is presented, encompassing the models for both AC/DC and DC/DC converters, as well as the Li-ion battery. Discussed the energy consumption of EVs from the grid as well as several optimization techniques for energy management, load shifting, peak shaving, and lowering the high power costs related to large-scale grid-based EV charging[1]. Additionally, an energy management and optimization system leveraging V2G systems to smooth fluctuations in large-scale wind power is designed and modeled in [2]. PV and wind serve as primary energy sources, to ensure continuous power flow. The variable nature of many renewable energy sources, such as solar and wind, can cause fluctuations in power availability. This highlights the need for advanced energy storage solutions to ensure a stable and reliable electricity supply [6]. In order to satisfy demand needs, power generation from renewable energy resources (RERs) is made possible in large part by energy storage (ES) systems [7]. Because RERs depend on external factors like wind and solar radiation, these systems aid in reducing the intermittency problems that arise.Furthermore, energy storage (ES) technologies provide numerous benefits beyond simply stabilizing the fluctuations of renewable energy resources (RERs). They are essential for improving power quality, voltage, and managing power variations. The proposed optimization approach is a hybrid heuristic technique created by combining two well-known algorithms: the Yellow Saddle Goat Fish Optimization algorithm and the Particle Swarm Optimization algorithm. The proposed hybrid optimization algorithm is named Yellow saddle Goat Fish-Particle Swarm Optimization. The settings of the battery current controller and the inner-loop voltage and current controllers for the interconnected converters were optimized using the suggested algorithm. MATLAB/Simulink was used to simulate the complete system, and the results were examined and shown. The system's performance and dependability are enhanced by this integration, making renewable energy a more viable and reliable choice for power generation.

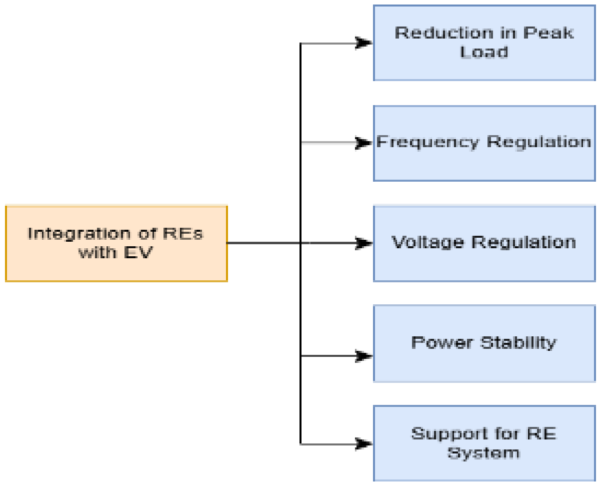

Fig.1. Benefits of Integrated Structure of REs with EV.

RELATED WORKS

Table.1 Representation Of Literature Survey

Author & Year	Findings	Techniques
Surabhi Bagherwalet.al 2024	Improving the robustness and stability of EV charging stations across varying conditions.	Lyapunov-based adaptive controller bridges
Shabab Saleem et.al 2024	Utilized to effectively harness the photovoltaic system by identifying its maximum power points (MPPs).	An artificial neural network (ANN)
Onder Tutsoy et.al 2023	To manage the simulation of the DC motor.	ant colony optimization fractional-order PID (FOPID) controller
Jamal El-bakkouri et.al 2022	Electric braking torque of electric vehicle's	ANFIS controller has been compared with AFPID controller
Aqeel Ur Rahman et.al 2021	Utilizing maximum state of charge of battery and supercapacitor.	The fuzzy logic-based energy management
Asif Khan,2020et.al	optimal unit sizing of a PV–WT–battery hybrid system to meet the consumer's load while minimizing the total annual cost (TAC).	A hybrid algorithm, combining Jaya and teaching–learning-based optimization (TLBO)
Ahmad Bagheri,et.al 2019	Optimizing SOC of the battery and UC	Differential Evolution (DE), and Cuckoo Search (CS)—
Carlos Henggeler Antunes et.al 2015	Optimizing the Energy management of energy storage System	fuzzy logic controller is designed using Particle Swarm Optimization (PSO).
Lorenzo Serrao et.al 2011	energy management problem in hybrid electric vehicles	Dynamic programming (DP) strategy is introduced.
S Zhang,et.al 2015	Minimizing the Battery state of charge, and minimum value of supercapacitors	particle swarm optimization to optimize the ESS.

2. MAIN OBJECTIVES OF THE CURRENT WORK

- To propose an improved version of HYSGFA by introducing Simplified formula to evaluate the next location in the process of iterations.
- To evaluate the capability of suggested HYSGFA in standard benchmark functions and Comparing YSGFA and PSO techniques.
- To implement the HYSGFA technique for Renewable energy sources integrated with electric Vehicle and demonstrate its SOC of the battery
- To demonstrate benefits of applying a FOPID over traditional PID controller.
- To assess the effectiveness of proposed controller in Electric vehicle.
- To examine the efficacy of HYSGFA based FOPID controller in three area system in Presence of appropriate nonlinearities.
- To examine the of proposed HYSGFA tuned FOPID controller at several loading conditions and with deviation in system parameter.

POWER SYSTEM MODEL

Hybrid System Composed of Various Components. The Proposed System Consist of Solar PV, Wind Energy Sources, battery, Controllers, Converters in Fig.2

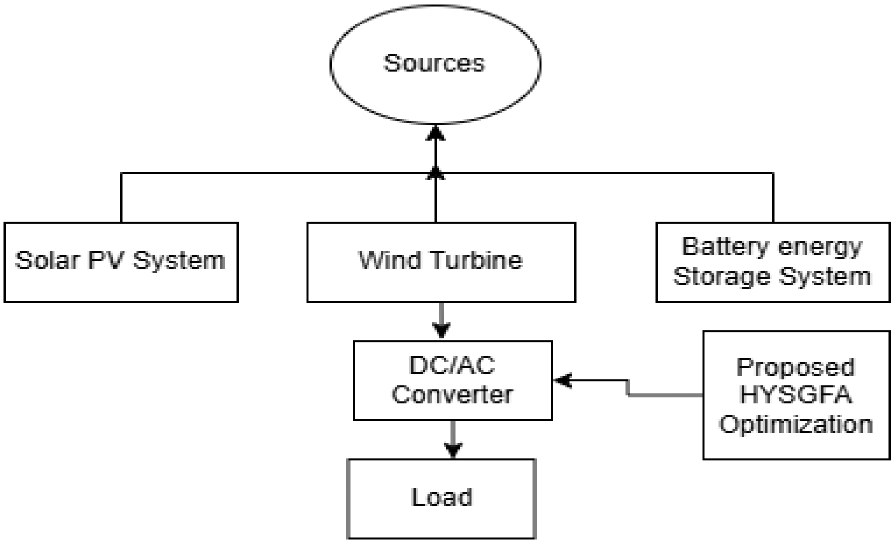

Fig.2. Internal Structure Block Diagram for a Renewable Energy Conversion System

A. Solar PV System

Renewable: Sunlight is an inexhaustible resource.

Clean: Solar PV produces no greenhouse gas emissions during operation.

Modular: Systems can be scaled from small rooftop installations to large utility-scale power plants.

Decreasing costs: The price of solar panel technology has decreased drastically in recent years.

B. Wind Generation Model

Wind energy is the fastest Growing and mostly used sustainable energy source for Power Generation. This model operates a permanent magnet synchronous machine with either three or five phases. The stator windings are connected in a wye configuration with an internal neutral point. In the three-phase machine, the back EMF waveform can be either sinusoidal or trapezoidal. For the sinusoidal machine, the rotor may have a round or salient-pole design.

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Table.2. Representation of Parameters of Wind Turbine Model

Parameters of Wind Turbine	Values
Nominal Mechanical Output Power	$5*10^3$ Watt
Base Power of Electric Generator	$5*10^3/0.9$ VA
Base Wind Speed	10 m/s

C. Electric Vehicle Model:
The Parameters for the Simulation were given. EV consists of three parts.

- One or more electric motors.
- Controllers.
- Charging system with a battery to store electric energy.

STRUCTURE OF FOPID CONTROLLER

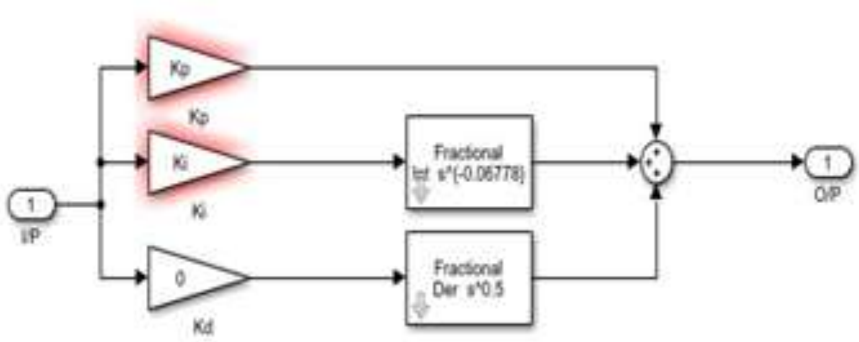

Fig.3 Internal Structure of FOPID controller

D. Equtions of FOPID Controller

The cornerstone of a FOPID controller is its transfer function in the Laplace domain:

C(s) = Kp + Ki * s^(-λ) + Kd * s^(μ)

Where:

- C(s) is the controller's transfer function.
- Kp is the proportional gain.
- Ki is the integral gain.
- Kd is the derivative gain.
- s is the Laplace variable.

λ is the fractional order of the integrator.

μ is the fractional order of the differentiator.

E. Key Differences from Traditional PID:
In a standard PID controller, the integral and derivative orders are always

1. In a FOPID, λ and μ can be any real numbers, providing greater flexibility in control.

2. Time-Domain Representation:

The time-domain representation of the FOPID control action can be expressed using fractional-order derivatives and integrals. This involves concepts from fractional calculus, which are more complex than standard calculus.

In the time domain it can be written as:
u(t) = Kp * e(t) + Ki * D^(-λ) * e(t) + Kd * D^(μ) * e(t)

Where:

- u(t) is the controller output.
- e(t) is the error signal.
- D^(-λ) represents the fractional-order integral.
- D^(μ) represents the fractional-order derivative.

F. Challenges and Considerations:
Implementation: Fractional-order operators are more challenging to implement than integer-order ones. Approximations and numerical methods are often used.

Tuning: FOPID controllers have five parameters (Kp, Ki, Kd, λ, μ), which makes tuning more complex than with traditional PID controllers. The FOPID controller expands the capabilities of the traditional PID controller by introducing fractional orders of integration and differentiation.

WHY HYSGFA OPTIMIZATION TECHNIQUE
The convergence characteristics in this figure show the average value of the convergence characteristics after we ran each method several times. Therefore, greater convergence characteristics may be obtained by improving the YSGA algorithm using PSO optimization techniques. In this way, it is shown to enhance the beginning position when used in conjunction with the metaheuristic algorithm, which is crucial for the method's rate of convergence.

Fig.4. Overview of HYSGFA Optimization Technique

METHODOLOGY

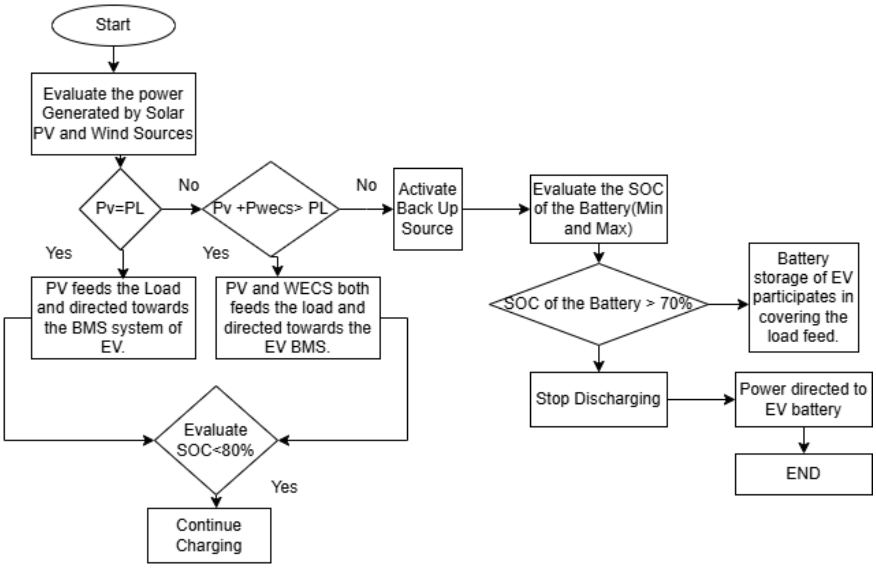

Fig.5. Flow Chart of the Methodology

CONVERGENCE CHARACTERISTICS

The convergence characteristics in this figure show the average value of the convergence characteristics after we ran each method several times. Therefore, greater convergence characteristics may be obtained by improving the YSGA algorithm using PSO optimization techniques. In this way, it is shown to enhance the beginning position when used in conjunction with the metaheuristic algorithm, which is crucial for the method's rate of convergence.

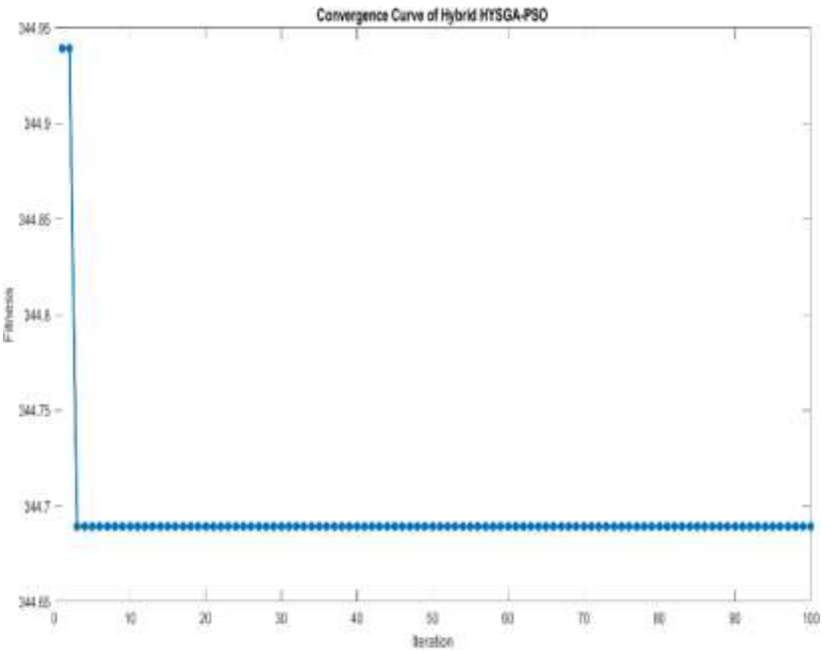

Fig.6. Convergence curve for the Proposed Model

RESULTS AND DISCUSSION

The proposed model's performance is analyzed using HYSGFA, considering variations in renewable power generation, including wind and solar thermal power. During the investigation Comparison of Voltage, current , Power and SOC of the Battery presented by using FOPID Controller under

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Optimization techniques. The battery state of charge considered is shown in Fig.9 From the analyzed parameters, there are many other factors influencing the range of an electric vehicle.

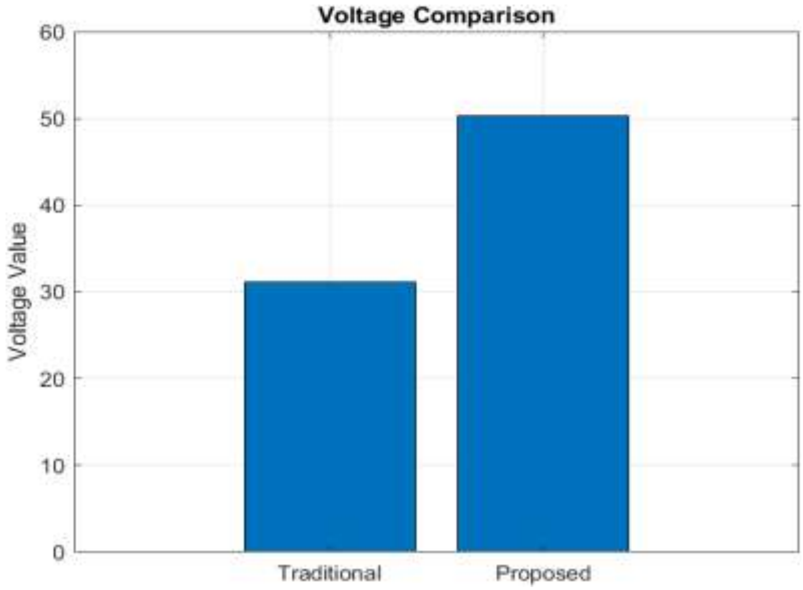

Fig.7. Comparison of voltage using Optimization Techniques

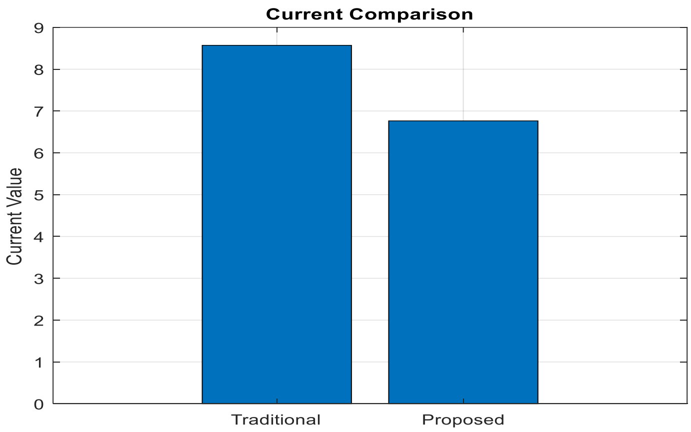

Fig.8. Comparison of Current using Optimization Techniques

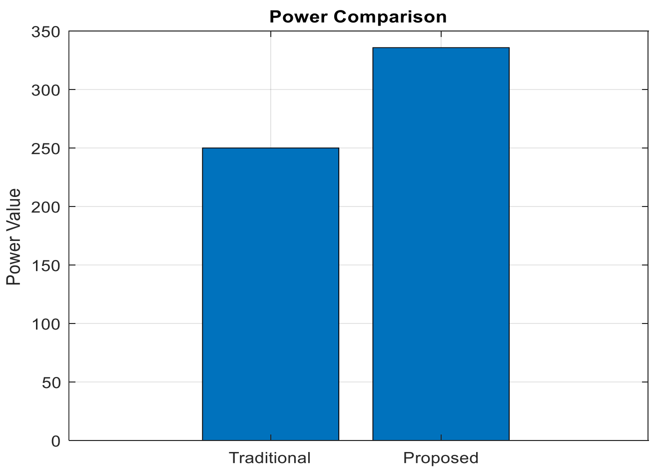

Fig.9. Comparison of Power using Optimization Techniques

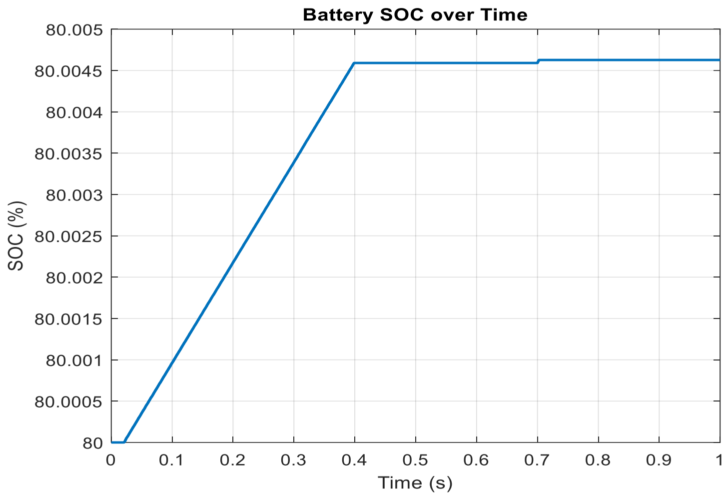

Fig.6. SOC of the battery by using Optimization Technique

CONCLUSION

Such an approach greatly speeds up the algorithm's convergence, as the article demonstrates.
Moreover, a novel goal function is introduced to ascertain the ideal FOPID controller settings.
Comparing the results of the suggested algorithm with the new goal function presented in this work, th e system's voltage responsiveness is noticeably superior than that of other methods under consideration. Simulation
system characteristics are changed to verify the resilience of the system with such an acquired FOPID co ntroller.
It is demonstrated that the step response exhibits minuscule deviations from the nominal case in every e xample studied, indicating that the system is resilient to system uncertainties.
Additionally, three frequently occurring disruptions are added to Regardless of the optimization issue being studied, we believe that this improves the approach. In this work, we evaluated its effectiveness and suitability for the optimum FOPID design problem Peak Time. Rise time, settling time, overshoot, are the primary indications of the step response quality. Additionally, the FOPID parameters that were acquired are also included in this category.

Table 2. Comparison of the System Parameters with FOPID Controller

Parameters	Improved Value with FOPID controller	Compared Values with PID Controller
Settling Time	0.3	0.9982
Rise Time	0.15	0.2422
Overshoot time	3	25.3455
Peak Time	0.5	0.89

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