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Constant Current Fuzzy Logic Controller for Grid Connected Electric Vehicle Charging

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ABSTRACT
The integration of electric vehicles (EVs) into the grid presents challenges related to efficient and stable charging processes. This research paper introduces a novel charging control strategy based on a constant current fuzzy logic controller for grid-connected EV charging systems. The proposed approach aims to optimize the charging process by regulating the charging current according to the EV battery's state of charge and the grid's capacity. By employing fuzzy logic, the controller adapts in real-time to varying conditions, ensuring consistent charging rates while preventing grid overload. Simulation results demonstrate the effectiveness of the constant current fuzzy logic controller in balancing the charging process, enhancing grid stability, and promoting sustainable EV adoption.

INTRODUCTION

The widespread adoption of electric vehicles (EVs) has necessitated the development of intelligent charging strategies that balance the charging process, grid stability, and user convenience. Traditional charging systems often lack the flexibility to adapt to fluctuating grid conditions and the varying state of charge of EV batteries. This paper proposes a constant current fuzzy logic controller for grid-connected EV charging, addressing the need for an adaptive, efficient, and stable charging solution. The constant current approach is chosen due to its reliability and compatibility with various EV batteries. The fuzzy logic controller is employed to dynamically adjust the charging current based on real-time inputs such as the grid's capacity, the state of charge of the EV battery, and user preferences. Fuzzy logic enables the controller to make decisions considering imprecise and uncertain information, making it suitable for handling the complex and dynamic nature of EV charging systems.

The paper delves into the development of the fuzzy logic controller, explaining the design considerations, membership functions, and rule sets. It emphasizes the controller's ability to maintain a constant charging current while intelligently adapting to grid constraints and EV battery conditions. By ensuring a consistent charging current, the proposed controller enhances the longevity of EV batteries and optimizes the charging time without compromising grid stability. The effectiveness of the constant current fuzzy logic controller is validated through comprehensive simulations, considering diverse scenarios such as varying grid loads, EV battery states of charge, and user

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demands. Simulation results showcase the controller's ability to prevent grid overload during peak demand periods and its capacity to adjust charging rates for different EV models and battery capacities. The adaptive nature of the fuzzy logic controller is a key strength, allowing it to handle uncertainties and fluctuations in the charging environment effectively. This research contributes to the evolution of EV charging technology by introducing an intelligent charging control strategy that combines the reliability of constant current charging with the adaptability of fuzzy logic. By promoting grid stability, enhancing user experience, and extending the lifespan of EV batteries, the constant current fuzzy logic controller offers a promising solution for grid-connected EV charging systems, facilitating the sustainable growth of electric mobility.

PROPOSED CONFIGURATION

The objective of the study on "MATLAB Simulation for On-Grid Electric Vehicle (EV) Battery Charger Designing Using Fuzzy and ANFIS" is to develop and evaluate a sophisticated charging system for electric vehicles. This study aims to employ advanced control techniques, specifically Fuzzy Logic and Adaptive Neuro-Fuzzy Inference System (ANFIS), to optimize the charging process. By utilizing MATLAB simulations, the objective is to design an efficient, reliable, and fast on-grid EV battery charger that can adapt to different charging scenarios and provide a seamless experience for EV users. The need for this research arises from the growing demand for electric vehicles and the corresponding need for robust, intelligent charging infrastructure. As electric vehicles become more prevalent, it is crucial to develop charging systems that are not only fast but also intelligent. Fuzzy Logic and ANFIS are well-known for their ability to handle complex and non-linear systems effectively. By implementing these techniques, this study addresses the need for smart charging solutions that can adjust charging parameters in real-time, ensuring optimal charging efficiency and battery life.

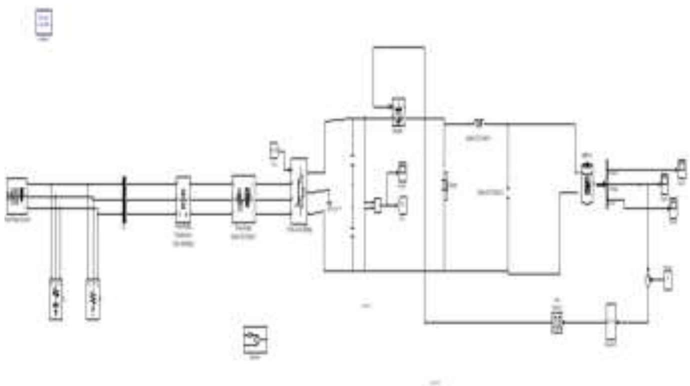

Fig 1 proposed system configuration

The introduction sets the context for the study by highlighting the increasing adoption of electric vehicles worldwide. It discusses the challenges associated with traditional charging methods, such as slow charging rates and lack of adaptability to different conditions. The introduction emphasizes the importance of intelligent charging systems that can enhance the user experience, reduce charging time, and contribute to the overall sustainability of electric transportation. It introduces the use of Fuzzy Logic and ANFIS as advanced control techniques that can address these challenges effectively.

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TABLE I. DESIGN PARAMETERS.

Parameters	Values
DC bus voltage	800 V
Inductance	21μH
Grid voltage	600 V
Transformer	600/240 V
Grid frequency	60 Hz
Battery SOC	50 %
Battery nominal voltage	300 V
Battery time constant	2 sec
Battery capacity	12 kWh
Short circuit level	30 MVA
X/R ratio	8
EV charging current	120 A

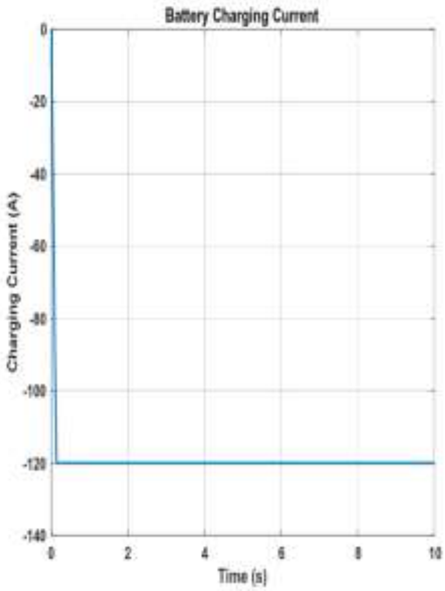

Fig 2 Battery charging current

Fuzzy Logic and ANFIS algorithms enable intelligent decision-making during the charging process. By analyzing various parameters, these techniques ensure efficient utilization of the grid power, leading to faster charging times. The proposed system can adapt to different charging scenarios, including variations in grid voltage, current demand, and battery conditions. This adaptability ensures consistent and reliable charging performance under diverse conditions.

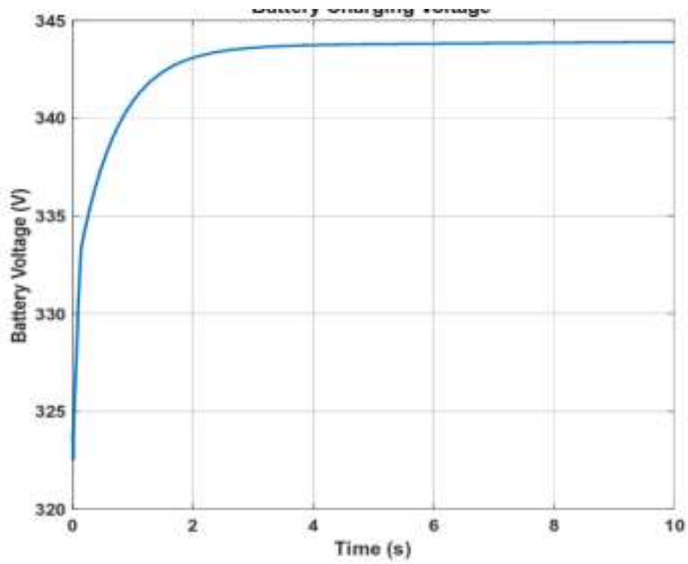

Fig 3 Battery charging voltage

By optimizing the charging process based on battery parameters, the system can extend the overall life of EV batteries. Smart charging reduces stress on the battery cells, minimizing degradation and enhancing long-term reliability. Fast and adaptive charging enhances user convenience, making electric vehicles more practical for daily use.

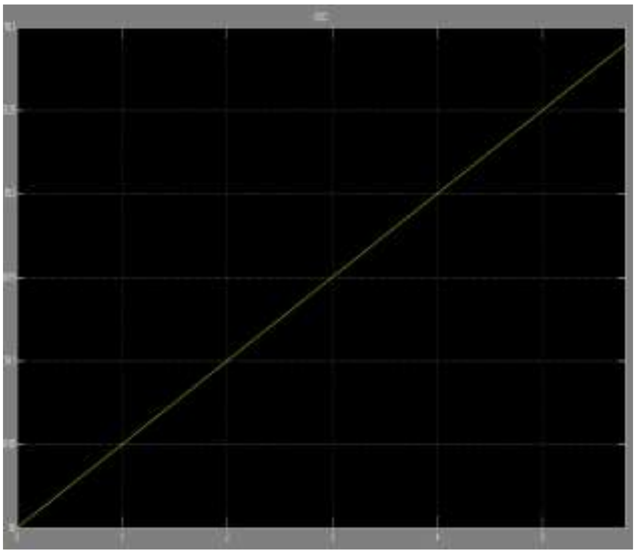

Fig 4 SoC for fuzzy(50% to 50.31%) based on-grid battery charger

The system provides a seamless charging experience, encouraging more people to switch to electric vehicles. The intelligent charging system is designed to be grid-friendly, meaning it can operate without causing significant fluctuations in the power grid. It optimizes power consumption, ensuring that the charging process does not strain the local electricity infrastructure. By promoting the use of electric vehicles through efficient charging solutions, the research contributes to reducing greenhouse gas emissions and promoting sustainable transportation practices.

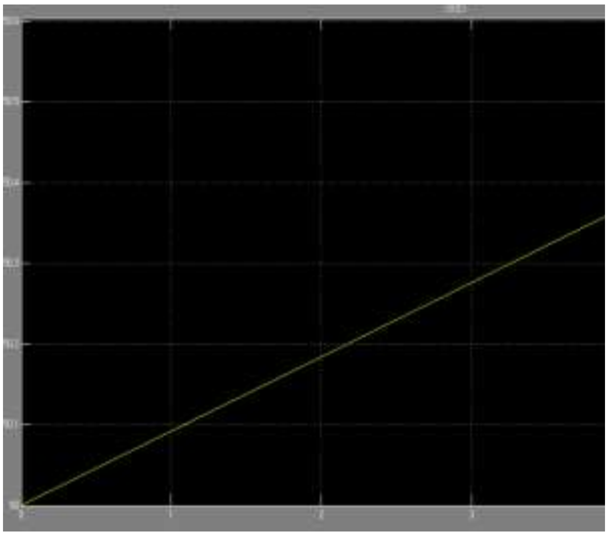

Fig 5 SoC for ANFIS (50% to 50.50%)/ based on-grid battery charger

CONCLUSION

The implementation of MATLAB simulations for on-grid Electric Vehicle (EV) battery charger design using fuzzy logic and Adaptive Neuro-Fuzzy Inference Systems (ANFIS) demonstrates the potential for intelligent and efficient charging systems. Through the integration of fuzzy logic and ANFIS algorithms, the charger can adapt to various conditions, optimizing charging efficiency and ensuring grid stability. In conclusion, this approach offers a robust and flexible solution for on-grid EV charging, providing benefits in terms of energy efficiency, grid management, and user convenience.

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