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Electric Vehicle Charging Station: A Simulation-based Study

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Abstract

Electric Vehicle (EV) is a current buzz in the automotive industry. As electric vehicles (EVs) become more widely used, there is an increasing need for reliable and easily accessible charging infrastructure. In order to meet the expanding demands of EV users while maintaining sustainability and scalability, this abstract describes the design and optimization of an infrastructure for electric vehicle charging stations (EVCS). The aim of this project is to design interfacing system between Electric Vehicle and Electric Vehicle Charging Station using MATLAB software. Since more and more people are using electric vehicles nowadays, it is imperative that their charging system must be robust and reliable so that one can use electric vehicle without any problem. A sustainable and effective way to address the changing needs of electric vehicle users, encourage the use of clean energy, and contribute to a more sustainable and greener future is through the design and optimization of the infrastructure supporting electric vehicle charging stations.

Keywords: Electric vehicle, Electric vehicle charging station, Automation, DC charging, Bi-directional DC-DC converter, State of Charge

INTRODUCTION

Throughout the past ten years, there has been a significant increase in demand for personal vehicles due to the growing global population. The need for oil has grown dramatically in recent years. The emissions from personal vehicles are another issue that is growing with time. Global warming, or the "greenhouse effect," is a severe problem that must be addressed. The energy crisis has led to heightened tensions in certain regions of the world [1].

Finding alternative sources of energy is imperative in order to ensure that future oil reserves do not run out. Electric vehicles are the most efficient forms of transportation because they emit no emissions from their tailpipes. Owing to the advantages of electric cars (EVs), there are currently 3 million of these vehicles on the road, and by 2030, 100 million are anticipated. However, in addition to massive energy, the suggested approach requires a large-scale charging infrastructure [2]. Hybrid electric vehicles (HEVs) are more energy-efficient compared to conventional automobiles because they maximize engine performance and collect kinetic energy while stopping. As concerns about climate change caused by greenhouse gas emissions have grown, so has the demand for low-polluting

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alternative energy sources. It has encouraged the concept of transportation electrification, that contributed to the popularity of electric cars (EVs) [3].

Electric vehicles, or EVs, are gaining popularity due to their potential benefits. These benefits include reducing carbon emissions in the transportation sector, which accounts for nearly 25% of total greenhouse gas emissions [4], encouraging the use of sources of renewable energy in the world's electricity generation mix [5], and enhancing the efficiency of energy use because the electric motors in electric vehicles (EVs) are more efficient compared to internal combustion engines in conventional vehicles. However, as EVs become more popular, the power infrastructure will have to accommodate larger loads. As a result, it is critical to carefully address charging control for large fleets of EVs [6].

In general, there are three types of EV charging: level 1 (slow charging), level 2 (fast charging), and level 3 (rapid charging).

Level 1 charging of electric vehicles (EVs) refers to the basic method of charging that utilizes a standard household outlet. Generally, Level 1 charging entails using the charging cable that comes with the car to plug the EV into a regular 120-volt AC electrical outlet. Although charging an electric vehicle (EV) at home with a standard outlet is the most convenient and accessible method, Level 1 charging is also the slowest. Based on the battery capacity and efficiency of the vehicle, the charging rate for Level 1 charging is generally quite low, offering approximately 2 to 5 miles of range per hour of charging. Level 1 charging is most appropriate for EV owners who can plug their car in for an extended amount of time and have access to overnight charging at home or at work. Though it might not offer enough charging for frequent use or long-distance travel, it is also helpful as a backup charger for sporadic top-ups while away from home. Even though Level 1 charging requires more energy than higher-level options, it is still a crucial component of the EV charging infrastructure, particularly for new EV owners who might not have access to dedicated charging stations. Furthermore, since Level 1 charging does not need specific charging equipment to be installed, it is frequently the most economical choice. All things considered, Level 1 charging offers EV owners a simple yet dependable way to keep their cars charged for daily use, making it an accessible and easy starting point.

When it comes to charging electric vehicles (EVs), level 2 charging is quicker and more effective than level 1 charging. Using a 240-volt AC electrical supply, level 2 charging is usually done with a specialized charging station that needs to be professionally installed. These charging stations can be set up in public parking lots, office buildings, and residential homes, among other places. The fact that Level 2 charging is substantially faster than Level 1 charging is one of its main benefits. Depending on the battery size of the car and the power output of the charging station, level 2 charging stations can provide an EV with power at a rate of between 10 and 60 miles per hour. Because of this, Level 2 charging is perfect for topping off the battery during the day while at work or running errands, as well as for overnight charging at home. There are several different types of Level 2 charging stations available, such as pedestal-mounted and wall-mounted models with integrated cables or connectors. They frequently have extra features like scheduling, monitoring charging sessions, and smartphone connectivity. It might be necessary to upgrade the electrical system in order to accommodate the higher voltage and current requirements for installing a Level 2 charging station. Nevertheless, a lot of electric utilities provide rebates and incentives to cover the installation costs, which increases EV owners' access to Level 2 charging.

According to research on the Chevrolet Volt, Level 2 EV charging is, on average, 2.7% more efficient than Level 1 charging. For shorter charge events that require less than 2kWh from the grid, the efficiency difference can reach 12.8% [7]. Hence in comparison to Level 1 charging, Level 2 charging offers EV owners a more flexible and expedient charging solution with faster charging speeds.

Level 3 charging, also known as DC fast charging or rapid charging, is the fastest charging option available for electric vehicles (EVs).Level 3 charging allows for significantly faster charging times by directly delivering direct current (DC) to the electric vehicle's battery, as opposed to Level 1 and Level 2 charging, which use alternating current (AC).When EV drivers need to swiftly refuel their cars after lengthy trips, level 3 charging stations are usually located near highways, important thoroughfares, and urban areas. These stations have high-power chargers that can produce up to 350 kW of power; however, charging rates can differ based on the battery technology and compatibility of the vehicle [8]. The primary benefit of Level 3 charging is its capacity to deliver a sizable amount of range in a comparatively short period of time. Long-distance driving and minimizing downtime on the road are made convenient for electric vehicle (EV) drivers by the fact that Level 3 charging can add 60 to 100 miles of range in just 10 to 30 minutes [9].

In contrast to Level 1 and Level 2 charging stations, Level 3 charging infrastructure is costlier to install and run. Furthermore, not every electric car can be charged at Level 3, as specific onboard charging equipment and ports are needed. Notwithstanding these drawbacks, Level 3 charging is essential to the broad use of electric vehicles as it offers EV owners quick and practical charging choices, particularly for those who depend on their cars for long-distance driving. Level 3 charging is anticipated to become even more common as infrastructure for charging devices grows and technology advances, which will hasten the shift to electric vehicles..

PROBLEM IDENTIFICATION

Electric vehicles (EVs) offer a viable environmentally friendly way to lessen reliance on fossil fuels and greenhouse gas emissions. Electric vehicles (EVs) are regarded as one of the most significant green solutions to the problems of rising carbon dioxide emissions and the scarcity of fossil fuels. Electric cars are more cost-effective and environmentally beneficial than conventional cars. However, the most common method for charging an electric vehicle (EV) at home is to plug it into the power supply. Since charging an EV requires a significant amount of power, the supply system in the home or office needs to be upgraded to support EV charging. Furthermore, the supply system becomes contaminated as a result of the enormous number of harmonics in the current that the EVs draw, which has an impact on the local office and household load. Moreover, many public locations, including parking lots, malls, and offices, allow EVs to be charged. Vehicle charging is therefore regarded as occurring at both residences and workplaces. When an electric car is plugged in, it usually begins to charge until it is fully charged. However, in using such a charging strategy, the transformer's maximum capacity may not be reached due to power consumption [10].

The lack of charging stations is the main deterrent for people against choosing electric cars. Unlike gas bunks, charging stations are not available everywhere. There is always a worry about what might occur if the car runs out of juice. In our nation, people are more concerned with expedient and straightforward modes of transportation than they are with protecting the environment from the damaging effects of pollution. As the number of EVs rises, more charging stations will be needed for the sustainable transportation. As global efforts intensify to combat climate change, this innovative charging solution emerges as a key enabler of sustainable and eco-friendly urban transportation.

PROPOSED METHODOLOGY

A Simulink model of an electric vehicle charging station is being proposed. As shown in Figure 1 the charging station and the electric vehicle is being represented by batteries respectively and the working of the proposed model is based on the State of Charge (SoC) method, with automation for the charging and discharging process of EV charging station.

The simulation for the automation process is shown in Figure 2. The automation is carried out using an OR gate. If the charging station's level of charge is less than 20% or more than 100%, the EV battery disconnects and the charging station charges; otherwise, the charging station discharges to charge the battery in the electric vehicle. A bidirectional DC-DC converter delivers the necessary bidirectional power flow for battery to charge and discharge. It can operate in both buck and boost modes and control power flow between two DC sources and a load. Given in Figure 3 is the bidirectional DC-DC converter which manages the flow of power between the charging station and the EV battery. When the charging station battery discharges it will work in boost mode while at the time of charging it will switch to buck mode based on the gate pulse provided.

Figure 4 and Figure 5 are the simulation models for the reference current generator for station charging and discharging respectively.

Reference voltage for the charging station is set to be the constant value which is the fully charged voltage of charging station and the present voltage of the charging station is being used to generate reference current for station charging by using Proportional Integral (PI) controller (Figure 4). Similarly, the desired EV output and the current state of voltage of EV is being used for the generation of reference current for station discharging by using Proportional Integral (PI) controller(Figure 5).

The reference current selector as in Figure 6 will select the reference current for charging or discharging on the basis of the value of state provided to it i.e. the signal from OR gate used in the automation.

Given in Figure 7 is the simulation model for the generation of pulse using Proportional Integral (PI) controller. The saturation of the PI controller is the maximum reference current which is the maximum charging current of the charging station. The pulse so generated is then fed to the gate terminal of IGBT used in the bidirectional DC-DC converter according to which the mode of bidirectional converter will shift i.e. the charging station will charge or discharge to charge the EV battery.

RESULTS

The proposed Simulink model, Figure1 is tested under different conditions to study the behaviour of the charging and discharging process of the charging station and the EV battery at different state of charge.

Figure 8 depicts the suggested model's graph while the charging station and EV battery are at 50% and 100% charge, respectively. In this condition the graph of the EV battery remains constant as its present state of charge is already 100 i.e. the maximum charge, while the charging station having present state of charge of 50 will get charged. Hence Figure 8 shows the charging process of the charging station, representing the state of charge of the charging station and EV battery with respect to time.

Figure 9 depicts the suggested model's graph while the charging station and EV battery are at 100% and 50% charge, respectively. In this case, the charging station battery discharges to recharge the EV battery. As a result, discharging reduces the charging station's state of charge, while charging improves the state of charge of the EV battery. As a result, Figure 9 depicts the charging station's discharging process as well as the charging of the EV battery, indicating the charging station's and EV battery's state of charge over time.

Figure 10 depicts the variation in state of charge of the charging station and electric vehicle battery over time when the charging station and EV battery have beginning states of charge of 10 and 30, respectively. Because the charging station's starting state of charge is less than 20, whatever the EV battery's state of charge is, it will remain unchanged until the charging station begins charging. Hence, Figure 10 displays the graph of charging of the charging station's battery while the graph of the EV battery stays constant.

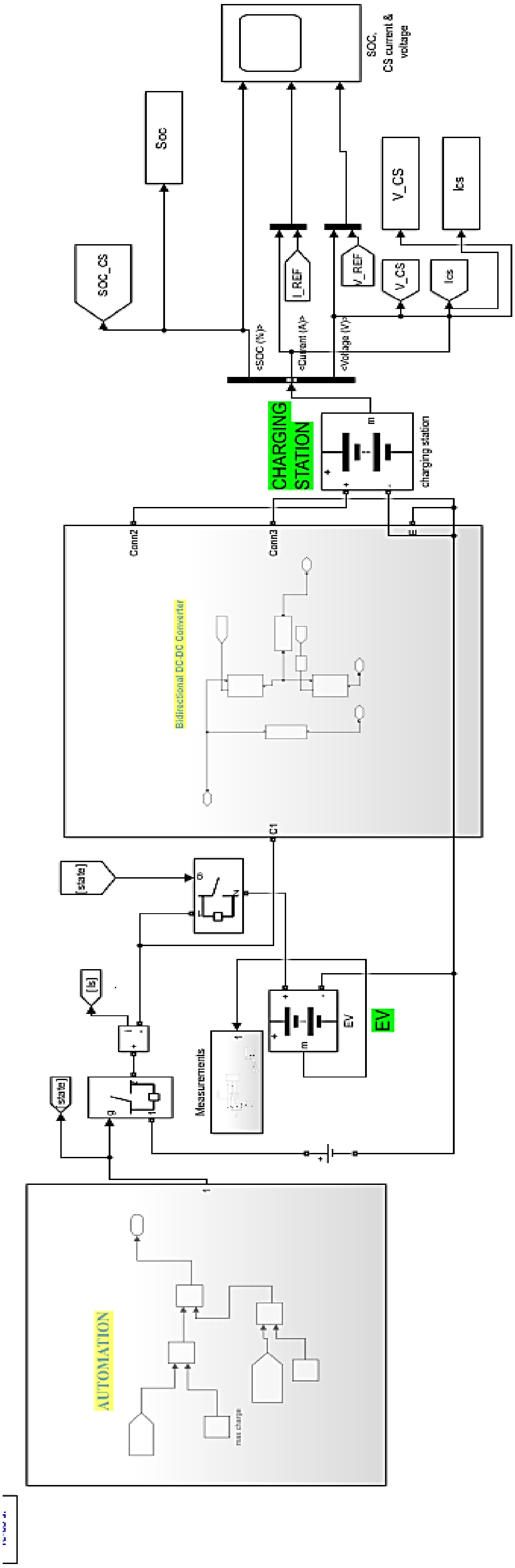

Figure 1. Simulink Model of the Proposed Charging Station.

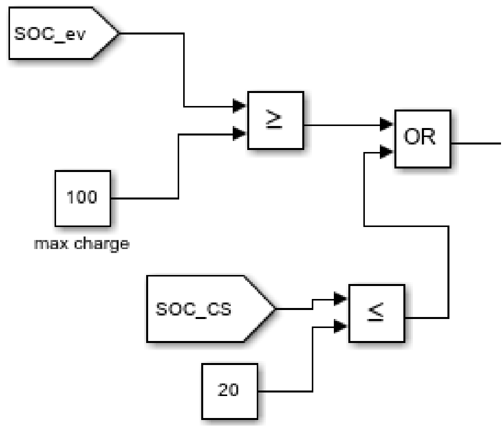

Figure 2. Automation using OR gate.

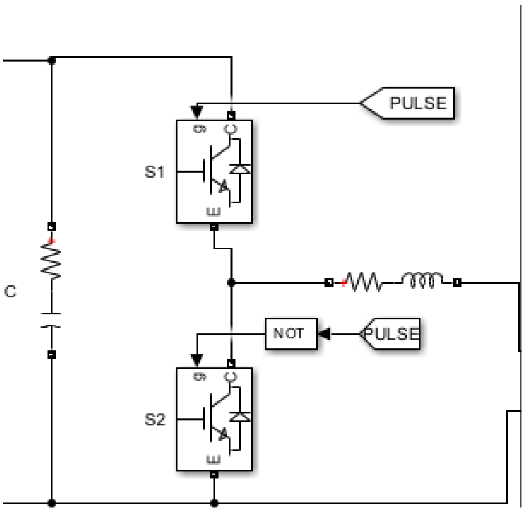

Figure 3. Bidirectional DC-DC converter.

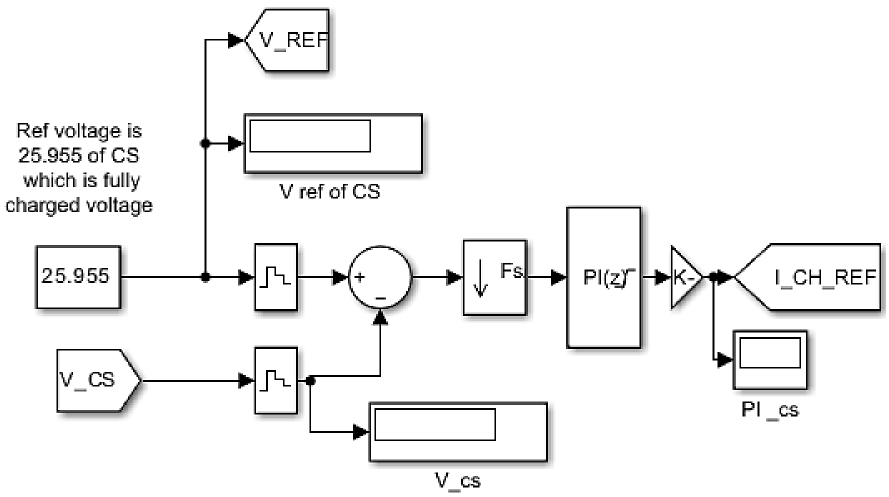

Figure 4. Reference current generator for station charging.

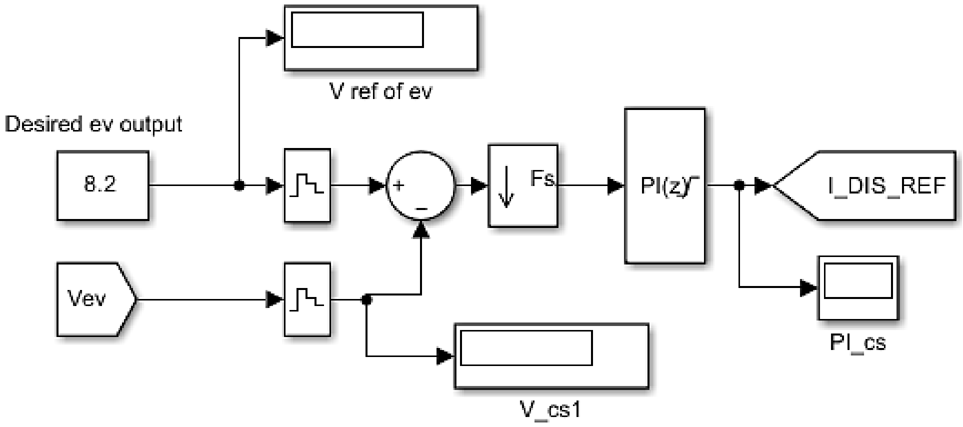

Figure 5. Reference current generator for station discharging.

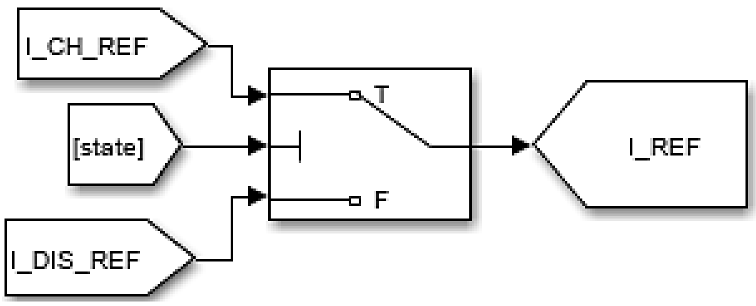

Figure 6. Reference current selector.

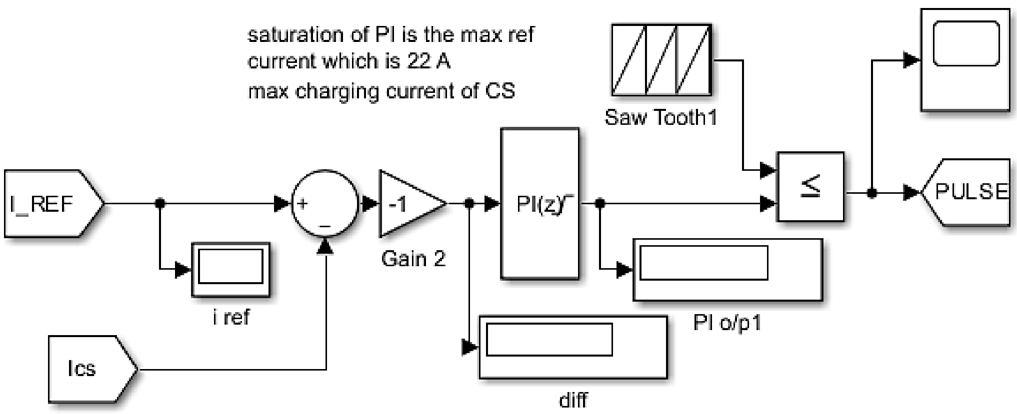

Figure 7. Generation of gate pulse.

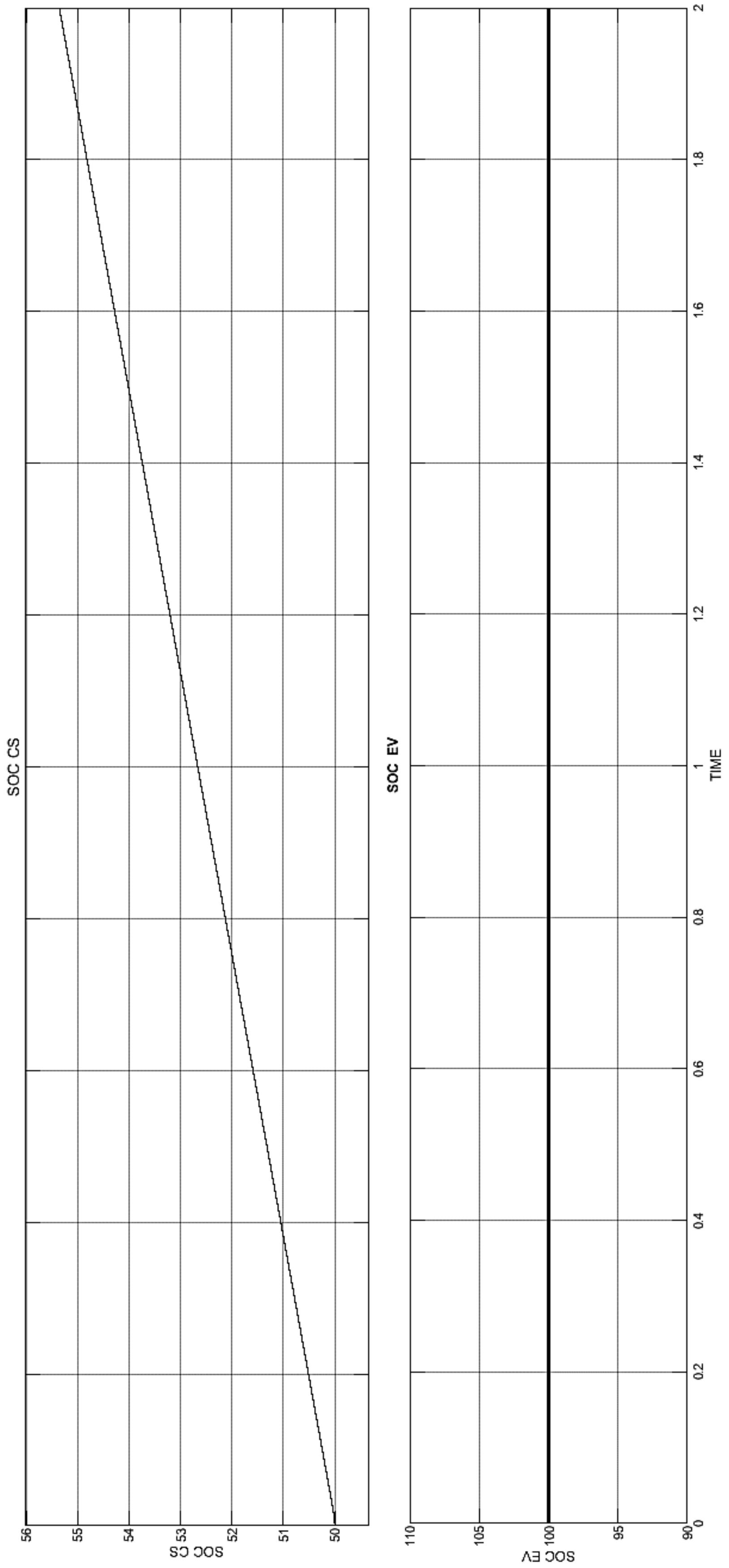

Figure 8. Variation in SoC of charging station and EV

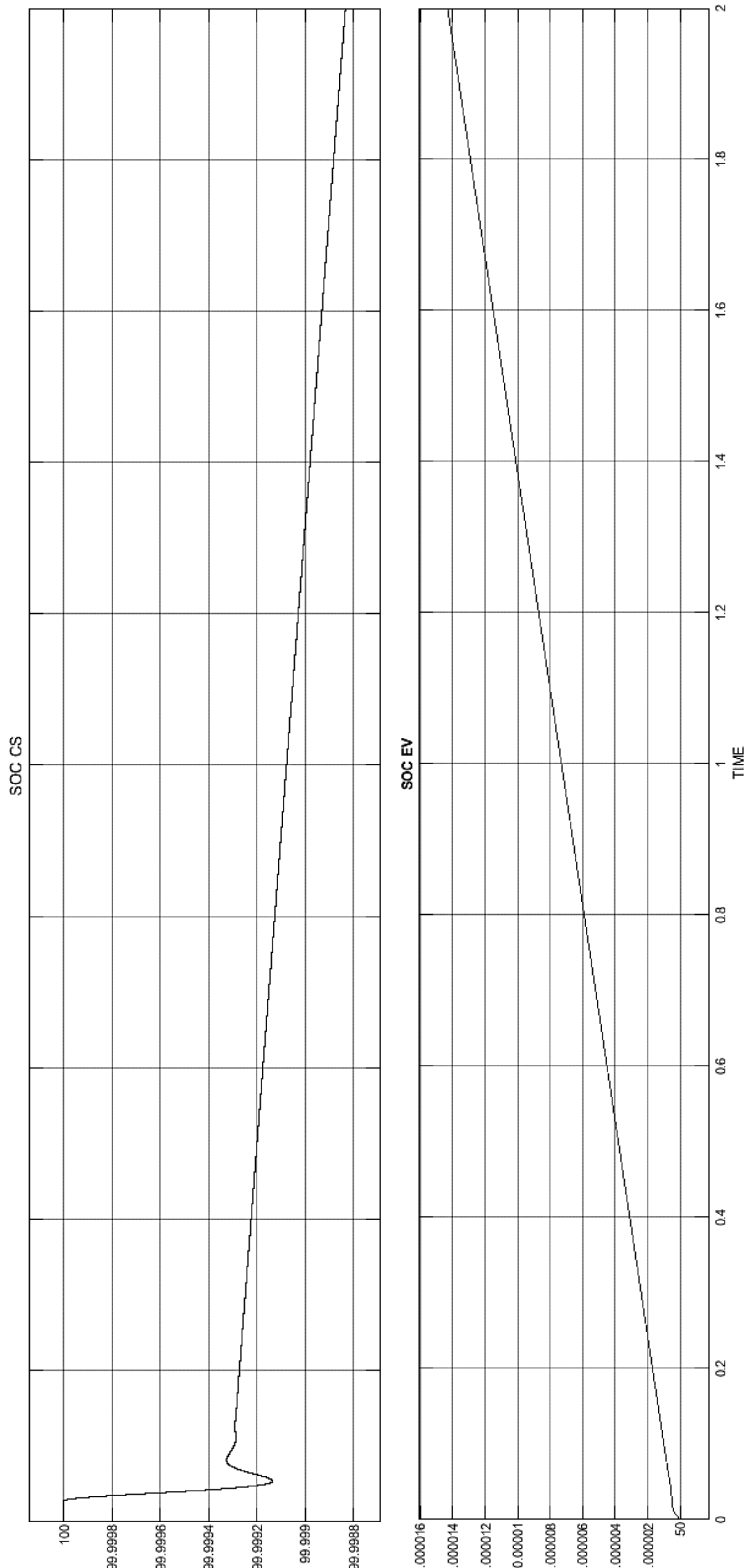

Figure 9. Variation in SoC of charging station and EV

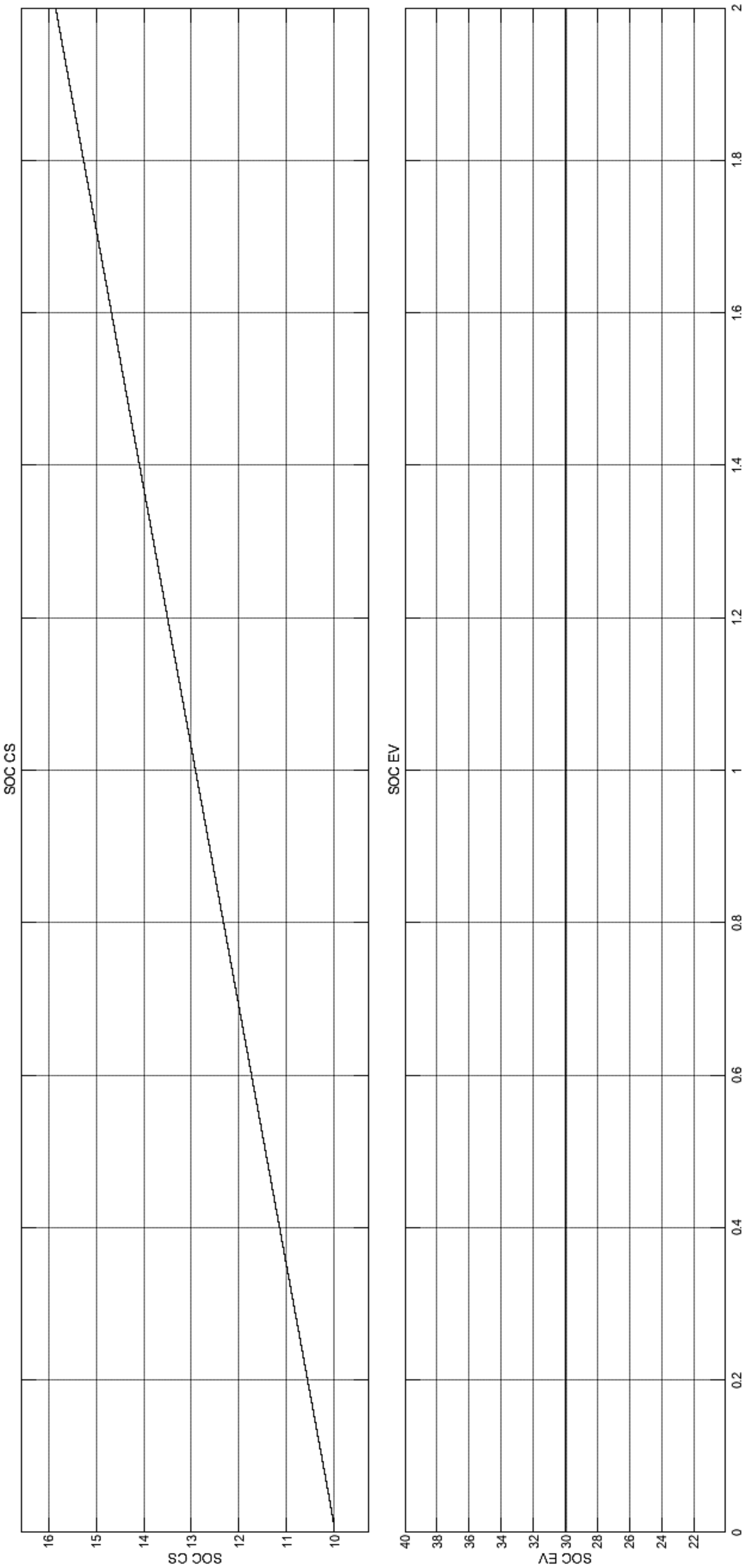

Figure 10. Variation in SoC of charging station and EV

CONCLUSIONS

The battery capacity of the charging station of the proposed model is 150 kW which can be modified according to the available supply. Moreover, the application of automation for the selection of charging or discharging process of the charging station battery and the EV battery prevents the overcharging condition of the batteries which results in increased efficiency and reliability of the proposed EV charging station model.

The growing global adaption of electric vehicles (EVs) has created a demand for EV charging stations. As the use of electric vehicles is increasing, so to ensure trouble free use of these vehicles their charging systems need to be strong and reliable. EV charging station also helps with issues like range anxiety and makes long distance driving easier. In addition, EV charging station facilitates the shift to environmentally friendly transportation.

REFERENCES

1. Chan, C. C. The State of the Art of Electric, Hybrid, and Fuel Cell Vehicles. *Proc. IEEE. 2007: 95(4): 704-718.*
2. *Shriwastava*, R., Kadlag, S. S. and Pawase, R. et al. Simulation analysis of electric vehicle charging station using hybrid source. *IJAPE*. 2024: 13(1): 2252-8792.
3. Biya, T. S. and Sindhu, M. R. Design and Power Management of Solar Powered Electric Vehicle Charging Station with Energy Storage System. 3rd International conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2019, pp. 815-820, doi: 10.1109/ICECA.2019.8821896.
4. Global EV Outlook 2017. International Energy Agency, 2017.
5. Al-Awami, A. T. and Sortomme, E. Coordinating Vehicle-to-Grid Services With Energy Trading. *IEEE Trans. Smart Grid*. 2012; 3(1): 453–462.
6. Lopes, J. A. P., Soares, F. J., and Almeida, P. M. R. Integration of Electric Vehicles in the Electric Power System. Proc. IEEE. 2011; 99(1): 168–183.
7. Sears, J., Roberts, D. and Glitman, K. A comparison of electric vehicle Level 1 and Level 2 charging efficiency. IEEE Conference on Technologies for Sustainability (SusTech), Portland, OR, USA, 2014, 255-258.
8. Augustin, B., Pinjari, A. R., Eluru, N., & Pendyala, R. M. (2015). Alternative Approaches for Estimating Annual Mileage Budgets for a Multiple Discrete-Continuous Choice Model of Household Vehicle Ownership and Utilization: An Empirical Assessment” forthcoming Transportation Research Record. Transport. Res. Rec.: J. Transport. Res. Board, 2493, 126-135.
9. Motoaki, Y., Yi, W., & Salisbury, S. (2018). Empirical analysis of electric vehicle fast charging under cold temperatures. *Energy Policy*, *122*, 162-168.
10. Speidel, S., & Bräunl, T. (2014). Driving and charging patterns of electric vehicles for energy usage. *Renewable and Sustainable Energy Reviews*, *40*, 97-110.

