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Development and Simulation of a MATLAB-Based Portable Charger for Electric Vehicles

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Abstract- **The design of a portable charger for electric automobiles (EVs) is carried out using MATLAB SIMULINK, a set of cutting-edge simulation tools. This abstract summarizes a simple, efficient, and dependable portable charging solution for EVs. To ensure compatibility and peak performance, the design employs MATLAB SIMULINK for component modeling and simulation. We examine methods for integrating complex power electronics, control algorithms, and charging procedures into our virtual environment in this abstract. By using the capabilities of MATLAB SIMULINK, the portable charger is intended to provide precise control, efficient power conversion, and seamless interaction with a range of EV models. To set the stage for discussing the simulation-based design approach in detail, this abstract will focus on how MATLAB SIMULINK helped create a portable charger that can adjust to the evolving needs of the electric vehicle ecosystem.**

Subjects: eco-friendly, user-friendly, energy-efficient, portable electric cars.

INTRODUCTION

The increasing number of electric vehicles serves as an example of sustainable mobility in the dynamic transportation landscape of the modern day. However, in order for EVs to become the mainstream, the issue of charging infrastructure must be addressed. In order to address this issue head-on, it is important to build a portable charger for electric vehicles. In order to build a portable, efficient, and user-friendly charging solution for electric car users, this introductory part will provide the framework for the future consideration of the various elements involved. We are seeking a portable charger that can be seamlessly incorporated into current infrastructure; this would serve to both facilitate the usage of electric vehicles (EVs) and contribute to the future sustainability of both urban and rural regions [1]. An important part of the automobile industry's new strategy for sustainable mobility is the widespread adoption of electric vehicles (EVs), which significantly reduce emissions and the need for fossil fuels. However, a key challenge to the widespread adoption of electric cars is the development of an easily accessible and comfortable charging infrastructure. A portable charger was created to circumvent this problem. because it's going to be really important for electric cars. To begin exploring the many facets of creating a portable charging solution that is both efficient and kind to the environment, we will cover the basics in this introductory part. In order to create a portable charger that adds electric cars to the growing number of people who own them, we will thoroughly research state-of-the-art technology, principles of compact design, and user experience [2]. For the electric vehicle (EV) market to thrive, there must be convenient and dependable charging solutions. In this first segment, we will explore the intricate process of developing a portable electric vehicle charger using the advanced simulation program MATLAB SIMULINK. As we navigate the complexities of contemporary transportation, the need for portable charging solutions has increased [3]. The goal of this design project is to create a portable charger that uses the power and flexibility of MATLAB SIMULINK to integrate state-of-the-art power electronics, intricate control algorithms, and best charging practices. We may test the charger's compatibility with various EV models by adjusting its performance in a simulated setting. By combining cutting-edge technology with MATLAB SIMULINK, we can create a future where electric vehicles are more accessible and eco-friendly. In this introductory section, we set the stage for a more detailed examination of the design complexities of a portable charger [4].

LITERATURESURVEY

The use of electric vehicles (EVs) has been increasing, according to Zhang et al., 2019. The demand for rapid-charging battery chargers is strong since they alleviate drivers' concerns about running out of energy. A novel rectifier type, the multipulse flexible-topology thyristor (mPFTTR), is presented here; it shows promise as a component of fast-charging battery chargers for electric vehicles (EVs) [5]. In order to assist rapid electric vehicle charging, Oruganti et al. (2019) investigated the best design and size for portable solar photovoltaic power plants. Our solar photovoltaic power plant can charge electric vehicles (EVs) with a simple plug-and-play operation. It is based on MATLAB/Simulink. To quickly recharge arriving electric cars, the system battery is used. one system. The large size and high cost of the chargers are two more issues that might slow the expansion of electric vehicles. The whole design process of a universal electric car charger was outlined by Al-Ogaili et al. (2019), with a focus on the control algorithms. Here, we present an off-board DC quick charger for EV batteries that employs a new management strategy to eliminate input voltage ripple and achieve zero output current ripple over the voltage range often seen in EV batteries [7]. In order to connect the battery to the dc-link (dc supply), the proposed quick charger configuration uses a modular three-phase interleaved converter, as stated by Hammami et al., 2019. [8]. The power supply approach for an XFC station, which can charge several electric cars (EVs) at once, was proposed by Iyer et al., 2020. A cascaded H-bridge converter is used to link directly with the medium voltage grid, and dual-active-bridge based soft-switched solid-state transformers are used to provide galvanic isolation

[9]. With the aim of creating a quick on-board charger for hybrid EVs and enhancing conductive charging, Gaurav et al. 2020 investigated the physical and electrical interfaces between EVs and EVSEs. They mainly set out to use Matlab to build a 3.45 kw on-board charger prototype that would adhere to industry requirements for electric cars and charging infrastructure [10]. Taghizadeh et al. (2020) developed and deployed an improved vehicle-to-vehicle (V2V) capability for use in situations requiring emergency roadside charging assistance. Specifically engineered for use with EVs, the charger is both multifunctional and single-phase. Since the planned EV charger is capable of handling the suggested V2V capabilities at rated power, a separate portable charger is unnecessary. Electric vehicles (EVs) were created and put into use for transportation when scientists became interested in green energy [11]. To facilitate bidirectional charging and several simultaneous charges, Evode proposed connecting EV charging stations to the grid in 2021 [12]. According to Maliat et al. (2021), electric vehicles may be equipped with a 48V onboard quick charging system. This solution eliminates the slow charging time of electric vehicles by operating in the Constant Current-Constant Voltage (CC/CV) mode, which takes around an hour to charge the battery. Using the MATLAB/Simulink model, the FBPS DC-DC converter is built, tested, and examined after the design process. The demand for electric automobiles is on the increase, as global sales more than quadrupled to 6.6 million in 2021 from 2.2 million in 2019 [13]. I. Problem Modeling There are a number of important obstacles to overcome while designing a portable electric vehicle (EV) charger in MATLAB SIMULINK. One of the most important aspects of a portable charger is how well it integrates power electronics components like inverters and converters. For this reason, MATLAB SIMULINK simulation models must be developed in order to examine and enhance the functionality of these parts. Second, for charging process management, it is crucial to develop strong control algorithms that include factors such as battery state-of-charge, voltage regulation, and temperature management. To guarantee correct and dependable charging in the dynamic environment of EV batteries, these methods are modelled and simulated using the MATLAB SIMULINK platform [14]. The construction and modeling of several charging protocols in MATLAB SIMULINK is necessary to assess their efficacy and integration potential, since the compatibility with diverse EV models is a big obstacle. An intuitive interface and smooth wireless communication, as modelled in MATLAB SIMULINK, are other essential components of an intuitive design that facilitates user engagement. Furthermore, optimization methods in MATLAB SIMULINK are required for the optimization of charging efficiency, taking into account variables such as battery properties and ambient circumstances. As a last step, a thorough life cycle analysis has to be conducted inside the simulation environment to determine the portable charger's environmental effect and sustainability. This will help evaluate its footprint and direct the usage of sustainable materials and energy-efficient components. An effective, suitable, and ecologically responsible portable charger for EVs is a goal of the problem formulation, which lays out a methodical strategy to tackling these complex issues [15]. Section B: Goals • To optimize energy efficiency via the design and modeling of a portable charger. Apply MATLAB to include an effective battery management system (BMS) into the charger's design. • Model the portable charger's user interface and control mechanisms in MATLAB.

METHODOLOGY

A methodical and iterative strategy integrating several phases of modeling, simulation, and optimization is used to build a portable charger for electric vehicles (EVs) using MATLAB SIMULINK. In order to find out what technologies are already out there, what problems people are having, and what works best, a comprehensive literature study is first done. Afterwards, the design process is guided by the definition of precise system requirements and specifications. Using MATLAB/SIMULINK to build a thorough model of the portable charger system is the meat and potatoes of the process. Power electronics parts, control algorithms, and various charging methods are all modeled in this model. Extensive modeling and fine-tuning are required for power electronics integration in order to maximize energy transfer efficiency [16]. The charging process is subsequently regulated by control algorithms that are written and tested in MATLAB SIMULINK. These algorithms handle variables including battery state-of-charge, voltage regulation, and temperature control. The charger's interoperability with multiple EV models is confirmed by simulating various charging protocols. At the same time, the UI is designed to provide intuitive controls and wireless connection. The system's resilience is evaluated by sensitivity assessments, and optimization studies are used to fine-tune the charging parameters for efficiency. Modeling the portable charger's lifetime in MATLAB SIMULINK is a crucial part of the technique for assessing its environmental effect and finding ways to make it more sustainable [17]. A thorough report outlining the technique, results, and suggestions for future development is the culmination of the last steps of the methodology, which include validation against real-world data, simulations with varied EV models, and thorough documenting of the whole design process. The many features of creating an innovative and efficient portable charger for electric cars may be thoroughly investigated utilizing this iterative and systematic process in MATLAB SIMULINK. Figure 1 displays the proposed project's technique in a step-by-step format.

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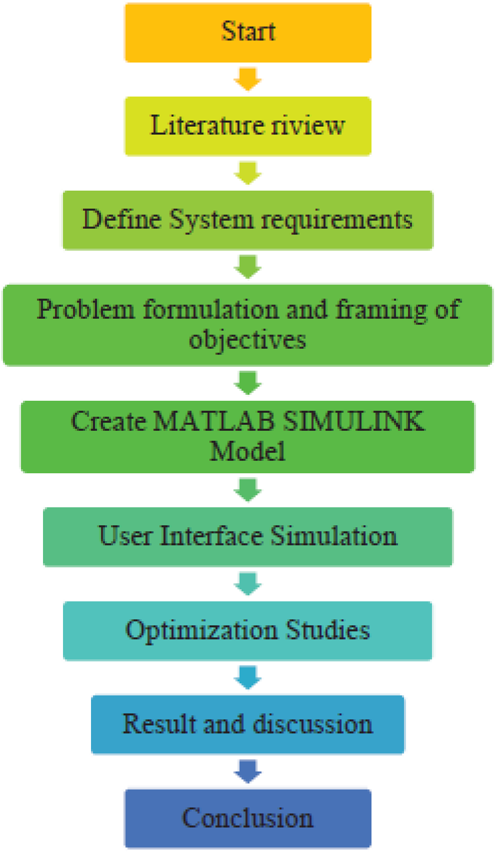

Fig. 1. Methodolgy flowchart

Section A: Planning and Drafting Figure 2 shows the several critical components that the MATLAB SIMULINK–designed portable charger for electric vehicles uses to guarantee effective and dependable charging. The charger relies on power electronics, namely inverters and converters, which are modelled and fine-tuned in the MATLAB SIMULINK environment. These parts are essential for the electric vehicle's battery to receive power from the charger. MATLAB SIMULINK was used to simulate the control system, which includes algorithms for accurate management of the charging process, temperature control, and regulation of the battery's state of charge [18]. Compatibility with various electric car models and industry standards is guaranteed via charging methods, which are also included into the simulation. The user interface component is designed to improve connection with the user and includes elements like wireless connectivity for easy and simple control. Furthermore, the charger may be optimized using MATLAB/SIMULINK to achieve optimum efficiency and flexibility by fine-tuning the charging settings. Ensuring the stability and efficacy of the Portable Charger for Electric Vehicles, the thorough simulation environment allows for a full investigation of each component's operation and interaction within the overall system.

Table 1 shows that the parameters-described electrical system has important features that characterize its functioning and performance. An input voltage of 325 volts powers the system, which runs at 50 Hz, the rate of electrical current alternation. A filtering capacitance of 6.23 microfarads (uF) is used to minimize voltage fluctuations and reduce ripple effects, ensuring reliable and smooth power supply. An output capacitor with a value of 110 uF further improves the output stability by storing and releasing electrical energy to keep the output voltage consistent. The system's DC link voltage is 400 volts, and the switching frequency is set at 20 kHz, which indicates that electronic components like transistors or switches are turned on and off rapidly. The system's rated power capacity, or maximum power output under typical working circumstances, is 2 kilowatts (kW). Incorporating a 160-volt battery inside the system gives it access to extra power. The electrical system is anticipated to be stable and efficient thanks to the use of a large DC converter capacitor with a capacitance of 6600 uF, which stores energy and smooths out the DC voltage.

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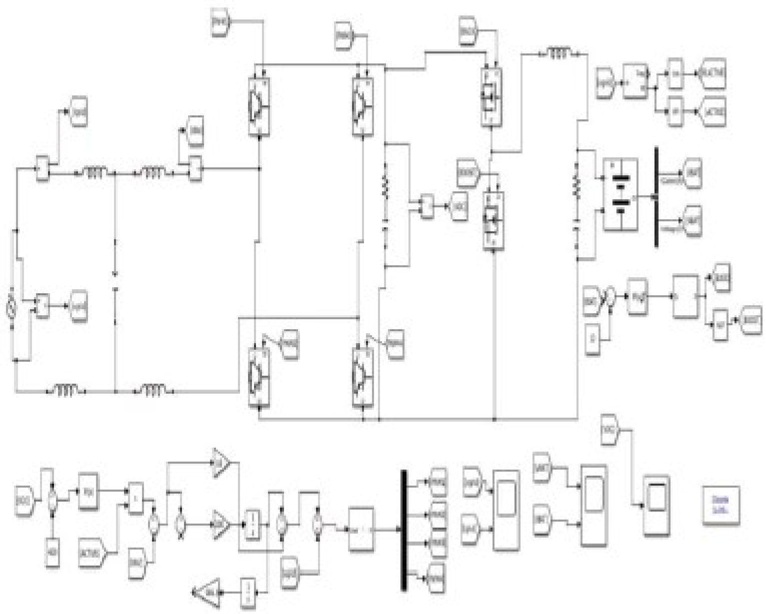

Fig. 2. MATLAB Simulink model for EV Charger

TABLE I. MODEL SPECIFICATIONS

Sr. No	Parameter	Values
1	Supply Voltage	325 V
2	Frequency	50 Hz
3	Filtering Capacitance	6.23 uF
4	Output Capacitor	110 uF
5	DC Link Voltage	400 V
6	Switching Frequency	20 kHz
7	Rated Power	2 kW
8	Battery Potential	160 V
9	DC Converter Capacitor	6600 uF

There are a number of crucial parts to the MATLABSIMULINK-simulated portable charger for electric vehicles that work together to make the system work well. Electronics for Power B. Building Blocks Turntables and Power Supplies: Fundamental to energy conversion and transfer, these components are modelled in MATLAB SIMULINK. In order to transmit power efficiently to the electric vehicle's battery, inverters change direct current (DC) to alternating current (AC), and converters change the input power to the necessary voltage [19].

$$V_D = D.V_{in} \quad (1)$$

Converter: Possible voltage conversion equations used in the mathematical form include Section C. Control Algorithms for the System: The algorithms that regulate the charging process are part of the control system that is modelled in MATLAB SIMULINK. Controlling temperature, monitoring battery charge, and regulating voltage are all important tasks that these algorithms do.

$$V_{out} = PWM.V_{dc} \quad (2)$$

They provide accuracy, dependability, and conditional adaptability in the charging procedure [19]. save power for the battery. By monitoring changes in temperature while the charger was in use, thermal analysis confirmed its dependability. The charger's robustness under different settings was shown by the sensitivity analysis. The findings demonstrate the practicality of the planned portable charger and its efficiency in various electric vehicle charging settings.

$$u(t) = K_p e(t) + K_i \int e(t)dt + K_d \frac{de(t)}{dt} \quad (3)$$

This study is significant because it adds to our understanding of how to build better charging infrastructure and because it shows how the system can be adjusted to fit the changing needs of the electric car market. Methods for Charging The charger can successfully interface with several electric car models thanks to the diverse charging protocols that are included into the simulation. By simulating several charging situations in MATLAB SIMULINK, we can verify that the charger is compatible with other systems and meets all relevant industry requirements [20]. User Interface (D) The GUI, or graphical user interface, was The user interface component, which is modelled in MATLAB SIMULINK, improves user engagement. The user may easily manage and monitor the charging process thanks to features like wireless connection. The charger can be easily communicated with and the user experience is guaranteed by the GUI [20]. E. Parameters for Optimization Studies on Optimization: MATLAB SIMULINK makes it easy to conduct studies on optimization, which lets you fine-tune the charging parameters. This part keeps the charger running smoothly by adjusting to various charging situations and reducing energy loss to a minimum. All of these parts work together to provide MATLAB SIMULINK a powerful simulation environment that we can use to investigate the Portable Charger for Electric Vehicles in great detail. A strong, efficient, and flexible charging system that can handle all the many kinds of problems with charging electric vehicles is what you get when these parts work together. An efficient and dependable portable charging solution may be achieved via the use of simulation, which allows designers to fine-tune and optimize the components before their actual installation [21].

$$f(parameter) = \frac{useful\ power\ out}{Total\ power\ IN} \quad (4)$$

The provided dataset shows a link between time and voltage, with seconds being the unit of measurement and volts being the unit of expression for voltage. An oscillation between positive and negative voltage levels is consistently shown by the data pattern. This voltage cycle repeats at a rate of -300 volts and 300 volts every 0.1 seconds. its periodic waveform, like an alternating current (AC) pattern, is suggested by its cyclic activity. The highest positive and negative numbers show that the amplitude of this waveform is 300 volts. Oscillatory patterns like these are typical of electrical systems and could, in this case, depict the actions of a circuit or voltage source that produces an alternating voltage signal. Because they provide light on the dynamic behavior of electrical systems over time (as shown in figure 3), understanding these time-voltage relationships is crucial in many domains, including electrical engineering and signal processing.

RESULTS AND DISCUSSIONS

A reliable and effective charging system was the end product of the planned project's design and modeling. MATLAB's simulation features made it possible to optimize charging methods, including constant current and voltage, by thoroughly investigating all possible design parameters. To improve charging safety and extend battery life, the integration of a BMS was successfully modeled. The charger's dependability was confirmed by thermal analysis, which measured changes in temperature while the device was operating. A sensitivity study proved that the charger could withstand different kinds of stress. The results demonstrate that the proposed portable charger is effective and highlight its potential for use in various real-world electric vehicle charging situations. In addition to advancing the state-of-the-art charging infrastructure, this study demonstrates how the proposed system can be easily modified to suit the changing needs of the electric car market.

TABLE II. AC VOLTAGE

Time(s)	Voltage(v)
0.1	-300
0.2	300
0.3	-300
0.4	300
0.5	-300
0.6	300
0.7	-300
0.8	300
0.9	-300
1	300

A reliable and effective charging mechanism was the end product of the project's design and modeling. The simulation features of MATLAB made it possible to optimize charging processes, including constant current and voltage, by thoroughly exploring all design factors. An effective model was developed to boost charging safety and include a Battery Management System (BMS). The data set in table 3 shows a connection between time and voltage, with seconds being the unit of measurement and voltage values reported in volts. It is clear from the statistics that the voltage drops steadily and gradually during the given time period. The voltage is 400 volts at the beginning of the measurement at 0 seconds and thereafter declines at regular intervals.

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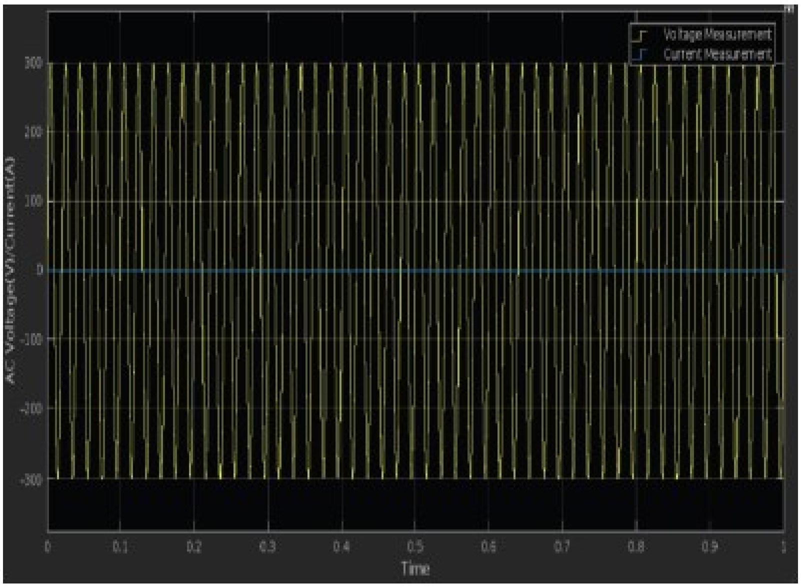

Fig. 3. AC Voltage Graph

The gradual decrease in voltage over time is indicative of a general decrease in electrical potential. The dataset's pattern points to a linear drop in voltage, which might be a sign of a discharge or relaxation in an electrical system. It seems that the readings are falling at a rate of around 10 volts every 0.1 second. The presence of a certain time constant in this pattern suggests that an electrical component or circuit is undergoing a discharge process. To analyze transient responses in circuits, discharge processes in electronic devices, or the behavior of certain kinds of energy storage systems, it is essential to understand the time-voltage connection. Modeling and simulating the electrical system's behavior using this dataset might help with the study and design of systems or components with comparable voltage decay characteristics over time, as illustrated in figure 4.

TABLE III. DC VOLTAGE

Time	Voltage
0	400
0.1	390
0.2	375
0.3	360
0.4	345
0.5	320
0.6	295
0.7	260
0.8	225
0.9	175
1.0	140

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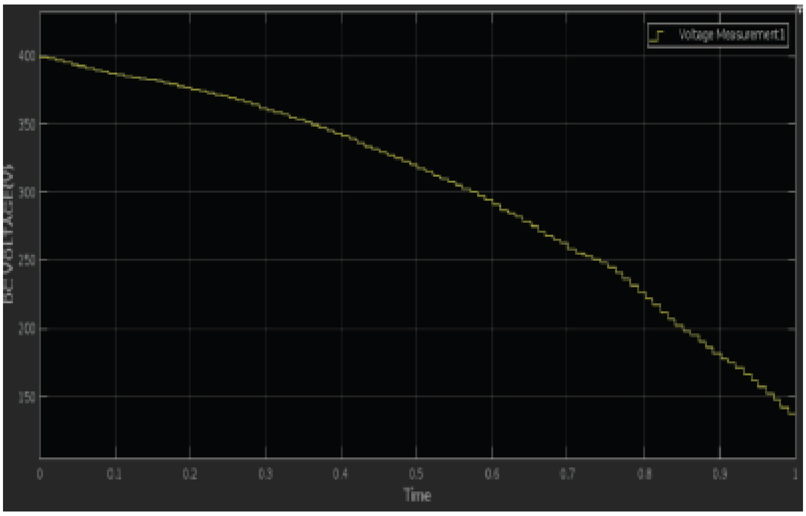

Fig. 4. DC Voltage

CONCLUSION

Their hard work has finally paid off with an adaptable and efficient charging system. Dynamic study of charging processes and systematic investigation of design aspects allowed for improvements in charging efficiency and battery life. Including a Battery Management System (BMS) and thorough temperature analysis demonstrated a commitment to reliability and safety. The charger's strong design is validated by sensitivity analysis, which demonstrates its resilience under many circumstances. Taken together, the results show how practical and versatile the suggested portable charger is, which is encouraging for its potential widespread application in many electric vehicle charging scenarios. This research contributes to what is already known about the charging infrastructure for electric vehicles and takes on the critical problem of providing efficient and reliable portable charging options in the ever-changing electric mobility industry.

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