



A REVIEW ON SMART ELECTRIC VEHICLE CHARGER AND CONTROLLER

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Abstract: This study has been undertaken to investigate the growing prominence of electric vehicles (EVs) necessitates advanced safety measures for battery systems and charging infrastructure. To address safety concerns, a sensor-based battery protection system is proposed, offering real-time monitoring of battery status, temperature regulation, controlled charging, and discharge display. Additionally, it facilitates locating nearby charging stations, presenting distance, and directions. Meanwhile, the demand for safer and more efficient EV chargers rises, emphasizing the need for comprehensive safety features to mitigate risks like overcurrent, overvoltage, overheating, and electrical hazards. This solution strives to enhance EV safety, sustainability, and user accessibility.

Index Terms – lithium-ion battery, charge controller, depth of discharge (DOD), state of charge (SOC), rectifier bridge, relay module, step-up & step-down transformer.

I. INTRODUCTION

The transportation industry has seen a change thanks to electric vehicles (EVs), which also portend an era of eco-friendly and efficient mobility. But the exponential rise in EV use has highlighted how urgently we need dependable, secure, and easy-to-use EV controls and chargers. Though promising, there are still issues, particularly about cost-effectiveness, environmental sustainability, and most importantly, making sure the charging systems have complete safety measures. Safety concerns have gained more prominence as the EV market grows. Events like battery fires in electric vehicles have sparked concerns about the viability of EV technology by 2022, especially about efficiency and safety. These events, which are frequently ascribed to battery explosions or fires, emphasize how urgently safety precautions inside the charging infrastructure must be improved. To overcome these obstacles, creative solutions strengthening the effectiveness and safety of EV charging infrastructure are needed. A possible option is to put in place a thorough system that is specifically made to protect batteries from anything that could start a fire. Numerous benefits targeted at reducing hazards and improving user experience are present in this system. This system's battery status monitoring and display feature, which offers current battery information, is one of its most important features. Important parameters including the state of charge, depth of discharge, charging status, and remaining charging time are included in this. Furthermore, the system integrates sophisticated charging algorithms to customize the charging procedure based on certain input factors, maximizing effectiveness and lowering hazards. An essential component of guaranteeing safety when charging is temperature monitoring. In order to reduce the risk of fire, the system is outfitted with automated cutoff mechanisms that avert overcharging, overvoltage, and overheating.

Additionally, it provides thorough insights into the charging and discharging statuses, giving customers all the knowledge, they need to make well-informed decisions. Furthermore, the system's capabilities extend beyond simple charging. To improve the ease and accessibility of EV charging, it has functions including estimating the remaining range depending on the current charge, pointing users in the direction of local charging stations, and giving distances and instructions. The charge controller, an essential part that controls the amount of electricity provided to the car's battery, is at the center of this safety system with the use of pulse width modulation (PWM) technology, this controller defends against overvoltage problems and stops overcharging. PWM

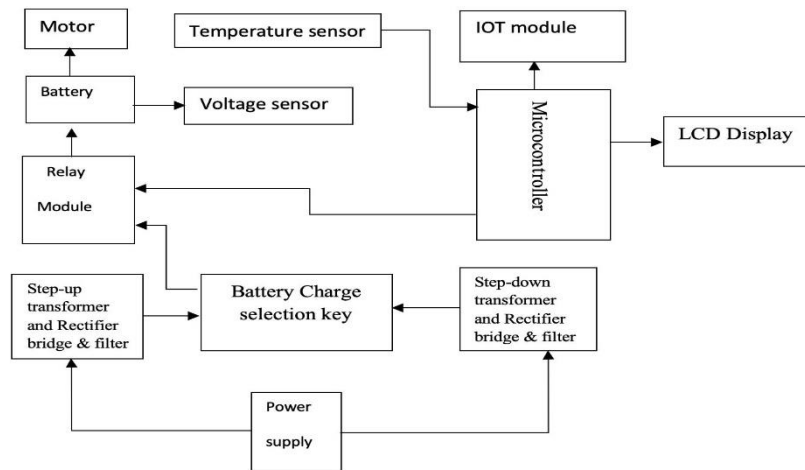
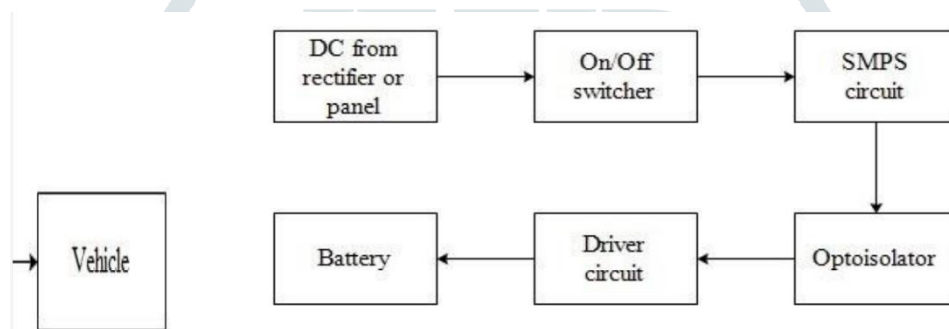


Figure 1.1. Block diagram of Smart EV Charger and controller

controllers optimize charging without sacrificing safety by progressively reducing the power input to the battery as it approaches full capacity. They are distinguished from Maximum Power Point Tracking (MPPT) controllers by their simplicity. To put it briefly, the incorporation of these cutting-edge safety measures and intelligent charging processes into the infrastructure for EV charging is a major advancement in reducing risks, improving efficiency, and guaranteeing a safer and more convenient future for electric vehicles.

Figure.1.2. Block diagram charge controller



In order to charge electric vehicle utilizing solar panels or a single-phase AC supply from the grid, a charge controller design is put forth in this work. It talks about two possible ways to charge: by rectifying a step-down AC voltage from the grid or by using direct voltage from solar panels. To control the charging process and avoid overcharging, a PWM-based charge controller is employed. A 48V, 20Ah battery was used for testing, and the results of charging voltage and current at various battery levels are shown.[1].

The context talks about designing an electric vehicle controller and charging circuits (2-wheeler battery-operated electric vehicle). It explains the essential parts of the circuit for charging the lithium-ion battery, including the relay, op-amps, transistors, and full wave rectifier. It also discusses the parts of the controller circuit, such as the MOSFET as the switching device, the IR2101 chip for controlling the MOSFET, and the PIC16F887 microcontroller for producing PWM signals to control the speed of the BLDC motor. It offers simulations of the charging and controller circuits together with block diagrams, circuit schematics, PCB layouts, and three-dimensional figures. It also offers the electric vehicle system's features, benefits, applications, and specs. [2].

Intelligent electric vehicle charger controller (IEVCC) described in this work has the ability to automatically modify the charging current or power in response to several criteria, including contracted power, residential electricity usage, and renewable energy production. A mesh version for multi-family structures and a single-user version for residences are detailed. The IEVCC employs the open OCPP standard for charging point communication and communicates via WiFi. According to experimental findings, the IEVCC dynamically modifies the charging current in response to actual household use in order to prevent going over the contracted power limit.[3].

This is a synopsis of the paper along with some queries: In brief: In order to maximise charging, the paper suggests a unique smart charge controller for electric cars that takes into account a number of variables. The neuro-fuzzy-PSO method is employed to ascertain the charge rate. When there are many inputs, a simple fuzzy logic controller gets complicated, so to reduce the number of rules, a neuro-fuzzy system is utilised. The controller response is then further optimised via particle swarm optimisation depending on goals like charging rate and profit. To calculate the charging rate, the suggested controller takes into account the needs of the user, the health of the battery, the output of renewable energy sources, the power tariff, and grid circumstances. The neuro-fuzzy PSO methodology, when compared to other methods, offers accurate charging rates with little computer complexity, as demonstrated by simulation and practical findings.[4].

In order to facilitate the use of electric vehicles, this study provides a location optimization technique for placing fast-charging stations beside national highways. It makes use of a greedy algorithm method and a geographic information system. Utilizing a "oil stain" distribution approach, even coverage can be attained with a minimal number of stations. Numerous variables are taken into account that impact the demand for pricing, such as population, traffic volume, services offered, and the distance to nearby stations. Using an installation potential calculation, the approach finds installation locations by evaluating existing rest areas as prospective sites. It is used as a case study in Hungary, and origin-destination traffic data is used for validation.[5].

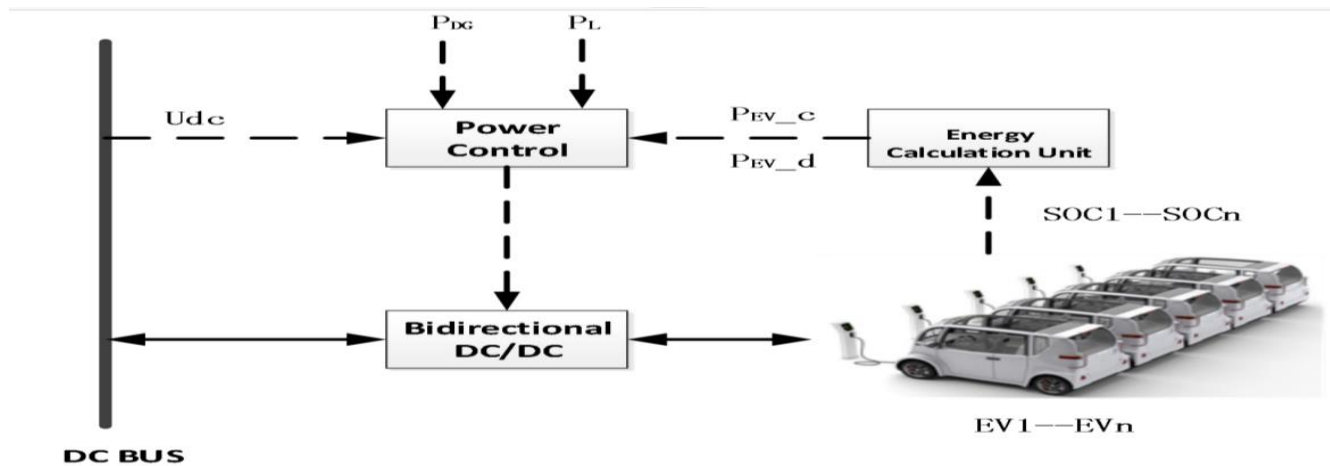


Fig.1.5. Charging and Discharging Control Strategy for Electric Vehicles

An autonomous DC microgrid system's charging and discharging control technique for electric vehicles was presented in this paper. It takes into account the charging-discharging models and the spatiotemporal peculiarities of electric vehicles. By using a variable power time division control approach, it seeks to achieve power balance and steady DC microgrid operation. The method uses the system power differential, the vehicle's current condition, load demand, and peak-valley periods to calculate when to charge and discharge electric vehicles. The strategy's ability to support power balance and enhance the use of renewable energy through peak filling and valley cutting was confirmed by simulation results.[6].

This research compares several optimisation methodologies and hierarchical multi-agent solutions to review regulated charging-discharging strategies for electric vehicle aggregators. In the future, V2G integration may be able to integrate the multistage decision approach to charging and discharging, which would help to reduce excessive charging costs and increase power factor and power quality. Reactive power management, peak load smoothing coordination, frequency regulation/cost minimization, peak load minimization, and other optimisation goals for charging-discharging control are covered. Additionally reviewed are heuristic optimisation techniques, model predictive control, and metaheuristic approaches. Adoption barriers for technology such as wireless charging are discussed, along with concerns about grid frequency regulation, commercialization, and military uses.[7].

In order to reduce the overall cost of energy consumption and comparable battery life loss, this study suggests a model predictive control-based energy management strategy (EMS) for plug-in hybrid electric vehicles (PHEVs) that takes into account an ideal battery depth of discharge (DOD). Using a shooting method and Pontryagin's minimal principle, the optimal DOD is found. Next, a reference state of charge (SOC) is built using the ideal DOD. At each step, a model predictive controller solves a local dynamic programming problem to optimise power distribution across a shifting horizon. The suggested EMS is tested with actual driving cycles under various preview horizons and is demonstrated to lower overall cost when compared to alternatives that do not use a rule-based approach or a battery ageing model.[8].

This study looks into the best places to put fast charging stations (FCS) for electric cars on the highway network in the United States. To optimize the percentage of long-distance trips completed, it formulates the problem as a mixed integer program, given station counts ranging from 50 to 250 and vehicle ranges ranging from 60 to 300 miles. A branch-and-bound technique is used to modify and solve the flow-refueling location model. Over 90% of trips with 150-mile vehicles and 250 stations were completed, according to the results. This offers a useful technique for FCS network planning.[9].

An Internet of Things-based battery monitoring system for electric cars is presented in this research. The system's objective is to remotely track and identify degradation in lithium-ion battery performance. It is composed of two components: a user interface that shows the battery state online and a monitoring device that measures battery voltage and utilizes a SIM808 module to determine position. Tests indicate that the device is able to acquire GPS locations and battery voltage. Through the use of discharge rates versus time measurements, it was also able to ascertain battery degeneration.[10].

The control of battery storage system temperature in electric vehicles is covered in this paper. It suggests an intelligent temperature control system to keep the battery chamber at the ideal temperature. The system senses the temperature and adjusts a cooling fan based on the data obtained from an LM35 temperature sensor and an ATmega16 microprocessor. By maintaining the battery at its ideal working temperature, it seeks to increase battery life and efficiency.[11].

In order to prolong battery life and enhance performance, the article suggests an electric car battery heat management system. It examines the relationship between temperature and several battery properties, including power dissipation, internal resistance, and discharge rate. It determines the needs for dependable and effective battery management solutions based on this. Rather than merely preserving a temperature range, it suggests actively regulating temperature at the cell level. In order to minimize stresses, the suggested method cools cells while not in use and heats them when high power is required. According to simulations, it can increase operating time over current systems by up to 58.4% without sacrificing security.[12].

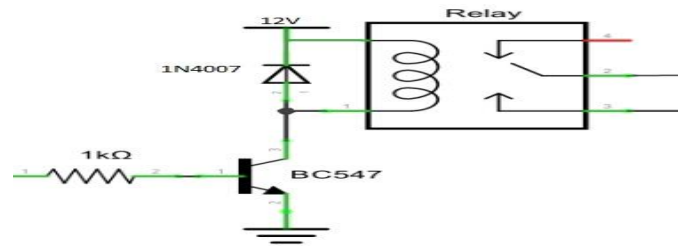
This paper presents a battery thermal management system using a liquid cooling method. It discusses the development of heat in batteries during charging and discharging and the need to regulate the temperature for better performance and lifespan. The system uses an Arduino microcontroller to monitor the battery temperature and a motor pump to circulate coolant liquid over cooling plates attached to the batteries when the temperature exceeds the preset level. Simulation and hardware results show that the cooling system is able to maintain the battery temperature within the optimum range.[13].

This is a synopsis of the paper along with some queries: In brief: An electric car battery monitoring system is covered in the document. It explains the system's hardware and software elements, including sensors for battery temperature, voltage, and current monitoring. An Android app is used to access the database once the data has been transferred over WiFi. This enables customers to keep an eye on the batteries' condition and level of charge in real time. The system's goals are to forecast battery life and offer

recommendations for the best possible charging. It also talks about how such a system may be integrated with battery rental companies to remotely control charging in response to on-time rent payments.[14].

Why charge controller particularly for Li-ion Batteries?

Lithium-ion batteries possess great energy density, light weight, and high reactivity. Compared to conventional batteries, lithium-ion batteries charge and discharge considerably faster. Lithium-ion batteries should not be driven above its safe operating



voltage range, which permits the battery to run within its safe operating range, in order to prevent a chain reaction of chemical reactions, an increase in temperature, cell venting, and fire. Charge controllers are widely used to control and manage the charging process in a variety of battery systems, including those that employ Li-ion batteries. The particular justifications for charge controller use, especially for Li-ion batteries, include:

- **Preventing Overcharging:** Overcharging Li-ion batteries can result in overheating, decreased performance, and safety risks. When the battery reaches its maximum voltage level, a charge controller monitors the voltage of the battery and makes sure that the charging process either stops or transitions into a controlled mode. This keeps the Li-ion battery from overcharging and increases its lifespan.
- **Temperature Regulation:** Li-ion batteries have ideal temperature limits for charging; charging beyond these ranges may result in safety concerns and performance deterioration. Temperature sensors are a common feature of charge controllers, which allow them to monitor battery temperature and modify charging procedures as necessary. If the temperature rises over safe thresholds, certain charge controllers have the ability to restrict the charging rate or stop charging altogether.
- **Preventing Over discharge:** Over discharging Li-ion batteries can lead to capacity loss and damage. Charge controllers can monitor the battery voltage during discharge and disconnect the load when the voltage drops to a predetermined level, preventing over discharge.
- **Current Limiting:** Regulation of charging currents is advantageous for Li-ion batteries. To avoid putting too much strain on the battery cells, charge controllers have the ability to limit the charging current. This is particularly crucial when charging a battery quickly or in situations where strong currents are applied to the battery, as these situations may arise.
- **Efficient Use of Solar or Alternative Power Sources:** Charge controllers are essential for maximizing the charging process in solar- or off-grid systems. They assist in matching the energy produced by solar panels or other renewable sources to the Li-ion battery's charging requirements. By preventing under- or overcharging, charge controllers make sure that the charging process is effective.
- **Load Management:** Certain charge controllers come with built-in load management capabilities. In order to safeguard the battery from over discharge or other unfavourable circumstances, they can control the power flow to the load and, if needed, disconnect it. This is especially crucial for systems that have simultaneous charging and discharging.
- **State of Charge (SOC) Estimation:** Circuitry for estimating the battery's state of charge (SOC) is frequently included in charge controllers. Users may better plan their energy usage and comprehend the battery's available energy with the aid of SOC estimate.
- **Safety and Protection:** Charge controllers provide protection against reverse polarity, short circuits, and other electrical defects, which enhances the general safety of Li-ion battery systems. They offer an additional degree of defense for the battery and any linked devices.

Topologies Of Integrated Charger

(1) Traditional AC/DC converter

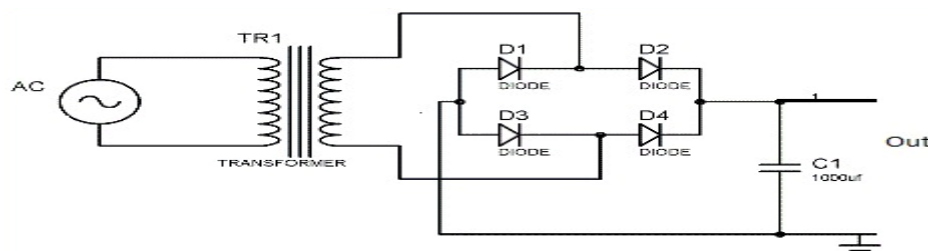


Fig.1.6. using Traditional AC/DC converter

A rectifier, also known as a conventional AC/DC converter, is a device that changes alternating current (AC) into direct current (DC). In order to supply a steady DC voltage for powering electronic circuits and devices, this conversion is frequently employed in a variety of electronic devices and power systems. Traditional diode-based rectifiers have several drawbacks, such as a comparatively high degree of DC output ripple, despite being straightforward and reasonably priced. Advanced converter topologies, such as switch-mode power supply (SMPS), can be employed to produce better voltage regulation and improved efficiency in more complex and demanding applications.

(2) Relay Circuit

Fig.1.7. Relay circuit diagram

A relay module is an electrical switch that is powered by an electromagnet. This device is composed of an armature, a coil, a spring, and one or more sets of contacts. Through the use of a relay module, the charge controller guards against overcharging and over voltages to ensure the battery is safe. The relay module can handle battery charging at up to 12 volts. The relay module is utilized for over-temperature auto cut-off and will trip or operate if the voltage exceeds 12 volts. It also stops charging.

II. CONCLUSION

The integration of a controller into electric vehicle (EV) chargers significantly enhances the efficiency, security, and user experience of the charging process. The controller plays a crucial role in power flow management, optimizing charging parameters, and ensuring infrastructure reliability. It can dynamically change charging parameters based on user preferences, grid conditions, and battery health, addressing battery degradation and lifespan concerns. This also allows for smooth connections between the EV and the charging station, enabling real-time monitoring, smart charging features, and remote diagnostics. The controller also ensures safety by automatically adjusting parameters to minimize overheating and potential risks. The integration of a controller in EV chargers aligns with the global movement towards a more environmentally friendly and sustainable mode of transportation, presenting electric vehicles as a trustworthy and feasible choice for various consumers. In conclusion, the controller-equipped EV charger is a critical first step towards a smarter, more efficient, and user-friendly charging ecosystem, promoting the widespread use of electric vehicles in the future.

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