



A Review of Study of Electric Vehicle Charging Station with Renewable Energy Source

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ABSTRACT-

The biggest thing that is happening in the world today is that global warming is increasing day by day. One of the main causes of global warming is the carbon emissions of conventional vehicles. One of the best solutions proposed compared to conventional vehicles is electric vehicles, because its advantages are zero carbon emissions, reduction of greenhouse gases, environment-friendly, zero use of fissile fuels. This paper helps to understand the configuration of a grid connected EV charging station which is integrated with a renewable energy system. It acts as a backup system to meet the power demand of a solar PV rooftop system and an EV charging station which helps to reduce the pressure on the grid. Renewable energy sources are the best solution as a local solution for power generation which helps to run the charging station economically as it cooperates with the grid connected charging station during off-peak hours.

Key Word- Electrical vehicle, Solar Photovoltaic system, Charging station, Backup battery.

INTRODUCTION

In times of energy crisis, where there was a shortage of traditional fuel sources, Electric Vehicles (EV) are an ideal solution, which is capable of balancing energy resources. Before adopting EV technology, there are concerns among people about limited driving range, long charging period and economic aspects. Before moving towards EV technology, infrastructure should be created for reliable operation of EVs, which includes charging stations and EV service stations. Charging stations play a vital role in EV technology so that the limitations of EV charging can be overcome. The location of the charging station should be a less accessible area, the charging time of EV should not be less and an ideal battery management solution should be implemented for a longer driving range. EV charging is a major and important aspect where charging can be done in two ways: on-board charging and off-board charging, where different levels of charging are set for DC charging. Charging stations require a huge amount of power from the grid to meet the needs of the station. One option to reduce the pressure on the grid is to adopt renewable energy sources. Integrating renewable energy sources with EV charging stations will help meet the power demand of EV charging stations.

Solar PV systems are one of the more popular renewable energy sources due to their convenience, reliability, low maintenance and easy installation. Integrating solar power with EV charging stations is a great combination to reduce pressure on the grid and the locally generated power can be easily charged by the solar PV system and used during peak hours of the grid so that the charging stations can run economically during peak hours.

The proliferation of electric vehicles (EVs) is a significant step towards reducing greenhouse gas emissions and combating climate change. However, widespread adoption of EVs depends on the availability of efficient, reliable and user-friendly charging infrastructure. Traditional charging methods, which mainly involve wired connections, often pose challenges such as physical damage, user inconvenience and potential safety risks. To address these issues, there is a growing interest in innovative charging solutions that can improve user experience and operational efficiency. This paper focuses on the design and simulation of an electric vehicle charging station using MATLAB/Simulink. The aim is to develop a comprehensive charging solution that includes both wired and wireless charging capabilities. MATLAB/Simulink, a powerful simulation tool, is used to model, analyze, and optimize charging station components and their interactions.

Power Electronics: Charging electric vehicle batteries requires efficient conversion of AC power from the grid to DC power. This includes designing rectifiers, inverters, and DC-DC converters that ensure minimal power loss and high reliability.

Wireless Charging Technology: Wireless charging based on inductive power transfer offers significant advantages in terms of user convenience and mechanical damage. The design involves modeling the inductive coupling mechanism, optimizing the alignment of the coils, and ensuring efficient power transfer.

Control System: An effective charge management system is required to monitor and control the charging process. This includes algorithms to estimate the state of charge of the battery, power flow control to prevent overcharging and overheating, and protection protocols.

Smart Grid Integration: Incorporating smart grid features can increase the functionality and efficiency of a charging station. Load balancing, demand

response, and energy storage integration are being explored to support grid stability and the use of renewable energy sources.

The MATLAB/Simulink environment provides a versatile platform for simulating these components and their interactions. By creating detailed models, simulations can predict charging station performance under different operating conditions, identify potential problems, and allow for optimization prior to physical implementation. This paper will present the design and simulation methodology of an EV charging station, along with technical details of the models used. The simulation results will demonstrate the effectiveness of the proposed design in terms of efficiency, reliability, and user convenience. Key performance parameters such as charging efficiency, power quality, and thermal performance will be analyzed and discussed.

LITERATURE REVIEW

The design and simulation of electric vehicle (EV) charging stations using MATLAB/Simulink is an emerging field driven by the need for efficient and reliable charging solutions. This literature review synthesizes original research on the components of EV charging infrastructure, the application of MATLAB/Simulink for system simulation, and advances in wired and wireless charging technologies.

EV Charging Infrastructure:- The development of EV charging stations involves many technical and engineering challenges. Recent research has focused on increasing the efficiency and reliability of both wired and wireless charging systems. The study by Khalig and Lee (2010) provides a comprehensive overview of the state-of-the-art of EV charging technology, highlighting the importance of power electronics and control strategies for optimizing the charging process.

Wired Charging Systems:- Wired charging systems are the most widely used method for EV charging. They involve a direct electrical connection between the charging station and the vehicle. Studies such as Chow and Wong (2016) emphasize the need for high-efficiency power converters to reduce energy losses and improve charging times. The integration of advanced control algorithms, as discussed by Yilmaz and Crane (2013), plays a key role in ensuring safe and efficient charging operations.

Wireless Charging Systems:- Wireless charging, or inductive power transfer (IPT), offers a more convenient alternative by eliminating the need for physical connectors. This technology has been the subject of extensive research due to its potential to increase user convenience and reduce losses. Researchers such as Kovic and Boyes (2013) have explored the design and optimization of IPT systems, focusing on the alignment and efficiency of power transfer. Additionally, dynamic wireless charging, in which vehicles charge while moving, has been presented by researchers such as Lukic and Pantic (2013) as an innovative solution to reduce EV downtime.

MATLAB/Simulink in EV Charging Design:- MATLAB/Simulink is widely used for the simulation and design of EV charging systems due to its powerful modeling capabilities and comprehensive toolset. The study conducted by Suryanarayana et al. (2018) highlights the effectiveness of MATLAB/Simulink in simulating power electronic circuits and control systems for EV charging infrastructure. The ability to model complex interactions and evaluate system performance in various scenarios makes MATLAB/Simulink an invaluable tool for researchers and engineers.

Power Electronics and Control Systems:- Power electronics play a critical role in the performance of EV charging stations. Efficient AC/DC conversion, as well as DC/DC conversion, are essential for optimizing energy transfer from the grid to the EV battery. The study conducted by Emadi et al. (2017) discusses in depth the design of high-efficiency converters and their control mechanisms. The integration of smart control systems, which monitor the battery's state of charge and manage the charging process by controlling power flow, is critical to ensure safety and efficiency.

Smart Grid Integration:- The concept of smart grid integration has gained popularity in the context of electric vehicle charging stations. Smart grids can facilitate load balancing, demand response, and the integration of renewable energy sources. Research conducted by Gellings (2013) explores the potential of smart grids in increasing the efficiency and sustainability of electric vehicle charging infrastructure. By incorporating features such as energy storage and real-time communication, smart grids can support more efficient and flexible charging networks.

BLOCK DIAGRAM

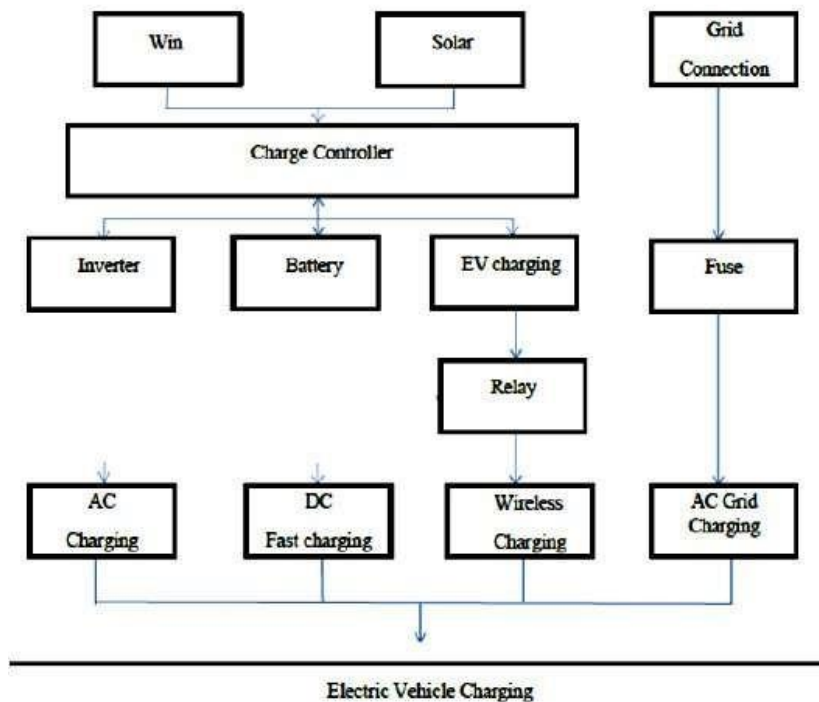


Figure 1. Block Diagram of Electric Vehicle charging station

BUCK CONVERTERS (DC-DC)

Only one switch is shown, for which a previously described device belonging to the transistor family is used. In addition, a diode (called free wheeling) is used to pass the load current when the switch (i.e., a device) is closed. The load is an inductive (R-L). In some cases, a battery (or back EMF) is connected in series with the load (inductive). Due to the load inductance, the load current must be provided a path, which is provided by the diode; otherwise, i.e., in the absence of the above diode, the high induced EMF of the inductance may damage the switching device, due to the tendency of the load current to decrease. If the switching device used is a thyristor, this circuit is called a step-down chopper, as the output voltage is usually less than the input voltage. Similarly, this DC-DC converter is called a buck converter, for reasons to be given later.

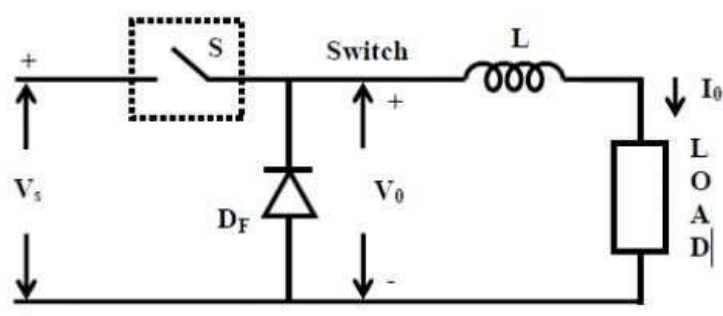


Figure 2. Buck Converter Line Diagram

RESISTORS

A resistor is a passive two-terminal electrical component that provides electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, divide voltage, bias active components, and terminate transmission lines. High-power resistors, which can dissipate many watts of electrical power as heat, can be used as part of motor control, in power distribution systems, or as test loads for generators. The resistance of a fixed resistor changes little with temperature, time, or operating voltage.

BATTERY CHARGER

The battery charger consists of a bi-directional converter along with the power electronic software and these work in harmony with each other and the respective control signals. A buckboost operation is performed in a converter, the buck-boost tree depends on the switching of the power electronic software. A boost action occurs at the voltage V_{bat} on the left side. When the lower software is powered or triggered and the upper software is powered off, the buck mode gets activated.

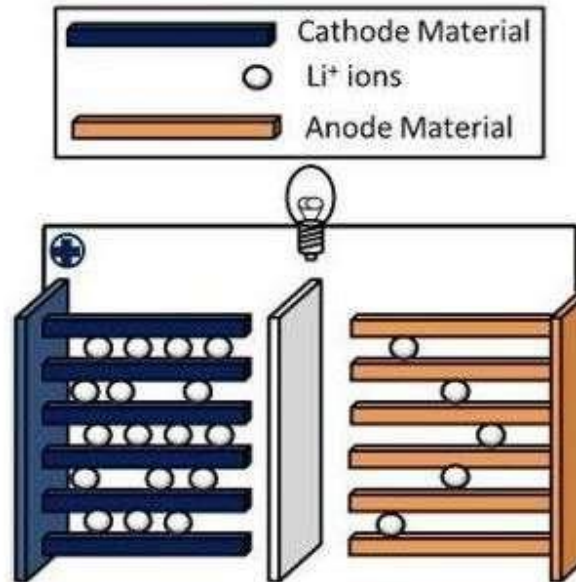


Figure 3. A lithium-ion battery

Lithium-ion batteries or Li-ion batteries are a type of rechargeable battery. Lithium-ion batteries are commonly used in portable electronics and electric vehicles. In these batteries, lithium ions move from the negative electrode to the positive electrode through an electrolyte during discharge and back during charging. Li-ion batteries use an intercalated lithium compound as the material in the positive electrode and usually use graphite in the negative electrode. These batteries have high energy density, no memory effect, and low self-discharge. Nominal, maximum, and cut-off voltages, these are some of the lithium-ion batteries that I have been using for a long time in many of my projects. Some batteries have a simple battery management system circuit for over-voltage protection, balanced charging, and short-circuit protection. Lithium-ion (Li-ion) batteries are an advanced battery technology that uses lithium ions as a key component in its electrochemistry. During the discharge cycle, the lithium atoms on the anode are ionized and stripped of their electrons.

CONTROL SYSTEM

The control system is an important aspect in modeling any system which monitors the operation of the system at different stages and adjusts the input values according to the system requirements to achieve the desired results. The inverter is used for power exchange between the AC grid and the DC bus. Cascade control implemented in the DQ frame is a control technique and the PWM generator is used to provide a gate pulse to the inverter software which helps in maintaining the DC bus voltage. The cascade control consists of an inner current loop and an outer voltage loop. The phase locked loop (PLL) is used for coordination with the grid voltage.

CONCLUSIONS

The control strategy used in the bidirectional inverter is also shown in the paper for proper understanding. The solar PV system is used for the economic and technical aspects of the station while the backup battery provides a solution to the peak hour power demand of the station which successfully reduces the pressure on the grid and the battery swapping facility can also be provided at the station. EV charging results are successfully demonstrated with different types of batteries which helps in studying and understanding the charging rate behavior with their respective structures.

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