DESIGN AND DEVELOPMENT OF SINGLE INPUT MULTI OUTPUT SYSTEM FOR ELECTRIC VEHICLE

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Abstract:

Proposed scheme developed in this project the primary objective of charging several batteries connected in single charging infrastructure using a logic sequences, power electronic switching device and its appropriate control scheme. Driven by the burgeoning electric vehicle (EV) market and its escalating need for advanced charging solutions, this project addresses the critical demand for efficient and scalable charging infrastructure. The core of this project lies in the creation of a novel charging scheme designed to intelligently manage and charge numerous batteries simultaneously within a single charging system. This will be achieved through the strategic application of a well-defined logic sequence, sophisticated power electronic switching, and a tailored control strategy to optimize the entire charging process. This innovative scheme prioritizes effective energy distribution, reduced charging durations, and heightened system dependability by dynamically managing power allocation across multiple batteries. Utilizing precise voltage and current regulation through power electronic switches ensures both safe and efficient charging operations. Moreover, an advanced control mechanism will meticulously coordinate the charging process, mitigating overloading risks, minimizing energy dissipation, and ultimately extending battery lifespan. The benefits of this approach are particularly pronounced in large-scale EV charging stations, fleet management scenarios, and grid-connected charging networks. It facilitates intelligent energy management through demand balancing, renewable energy integration, and support for vehicle-to-grid (V2G) functionalities. In conclusion, this project aims to deliver a scalable, efficient, and smart EV charging solution that directly supports the sustainable transportation needs of the future.

Introduction:

The rapid growth of electric vehicles (EVs) has created a strong demand for efficient, compact, and intelligent power electronic systems. Modern EVs rely on multiple subsystems such as traction motors, lighting, infotainment, battery management systems, and auxiliary loads, each requiring different voltage and power levels. Traditionally, these loads are powered using separate converters, which increases system complexity, cost, size, and energy losses.

To address these challenges, the concept of a Single Input Multi Output (SIMO) power conversion system has gained significant attention. A SIMO system utilizes a single energy source—typically a battery—and efficiently distributes power to multiple outputs with varying voltage and current requirements. This approach reduces the number of individual converters, leading to improved system integration, reduced hardware components, and enhanced overall efficiency.

In the context of electric vehicles, implementing a SIMO system can significantly optimize energy utilization and simplify power management. It also contributes to reduced weight and space requirements, which are critical factors in EV design. Moreover, advanced control strategies can be incorporated to regulate multiple outputs simultaneously, ensuring stable operation under dynamic load conditions.

This project focuses on the design and development of a Single Input Multi Output system for electric vehicles, aiming to create a reliable, efficient, and cost-effective power distribution solution. The system is designed to support multiple loads from a single battery source while maintaining high performance, voltage regulation, and safety standards.

Related Works:

Several research works have been carried out in the field of DC-DC converters and multi-port power conversion systems for electric vehicle (EV) applications. These studies mainly focus on improving efficiency, reducing component count, and solving control challenges such as cross-regulation.

Early work on SIMO converters highlighted the need for replacing multiple individual converters with a single integrated system. A study proposed a non-isolated SIMO buck converter capable of converting a 48 V input into multiple outputs (such as 12 V and 5 V) for EV subsystems like lighting and control units. This approach reduced switching losses and overall system cost while improving efficiency.

Further advancements introduced multi-output DC-DC converter topologies that overcome traditional limitations such as duty ratio constraints and inductor current imbalance. A notable contribution demonstrated a SIMO converter capable of generating multiple independent output voltages without cross-regulation effects, ensuring that variations in one load do not affect others. Another important work focused on the design and implementation of SIMO converters for EV auxiliary power modules, where a compact system delivered outputs like 24 V and 14.4 V from a single 48 V source. The study emphasized simplified control strategies and elimination of cross-regulation, validated through simulation and hardware prototypes.

Researchers have also explored multi-load and multi-source converter systems, integrating renewable energy sources such as solar power along with batteries. These systems demonstrated improved efficiency, stable voltage regulation (within ±1%), and the ability to independently control multiple loads like motors, air conditioning, and lighting systems in EVs.

To address these challenges, recent designs propose advanced topologies with fewer switches, improved voltage gain, and better load isolation, making them more suitable for modern EV applications.

Moreover, research in multi-port and hybrid converters shows that integrating multiple inputs and outputs can enhance system flexibility and energy management, especially in hybrid electric vehicles and renewable-integrated systems. These converters achieve high efficiency (up to ~96%) and support bidirectional power flow.

The development of Single Input Multi Output (SIMO) DC-DC converters has gained significant attention in recent years, particularly for electric vehicle (EV) applications where multiple voltage levels are required from a single battery source. Researchers have explored various converter topologies, control techniques, and design optimizations to improve efficiency, reduce cost, and enhance performance.

Methodology:

The existing charging infrastructure in India across the world. The chapter analysis charging speed, range, demand spike, voltage sag and swell and lack of smart charging. This chapter analysis the market strategy of Indian Automobile marketuptotheyear2030 and its power requirement. This chapter provides statistical information about registered EV's in Indian road. This chapter indicates ARAI standard of electric charge in the form of AC and DC and method of charging, SOP for charging infrastructure.

System Architecture:

The system architecture of a Single Input Multi Output (SIMO) system for electric vehicles is designed to efficiently distribute power from a single battery source to multiple subsystems with different voltage requirements. The architecture primarily consists of an input DC source (EV battery), a SIMO DC-DC converter, a control unit, output filters, and multiple load terminals. The battery provides a constant DC input, which is processed by the SIMO converter using switching elements such as MOSFETs, inductors, and diodes to generate multiple regulated output voltages. A control unit, typically implemented using a microcontroller, generates Pulse Width Modulation (PWM) signals and uses feedback from each output to maintain stable voltage levels. The output filters, composed of inductors and capacitors, reduce ripple and ensure smooth DC supply to the loads. These outputs are then used to power various EV subsystems such as lighting, control electronics, and sensors. This architecture reduces the need for multiple individual converters, thereby minimizing system complexity, cost, and size while improving overall efficiency and reliability

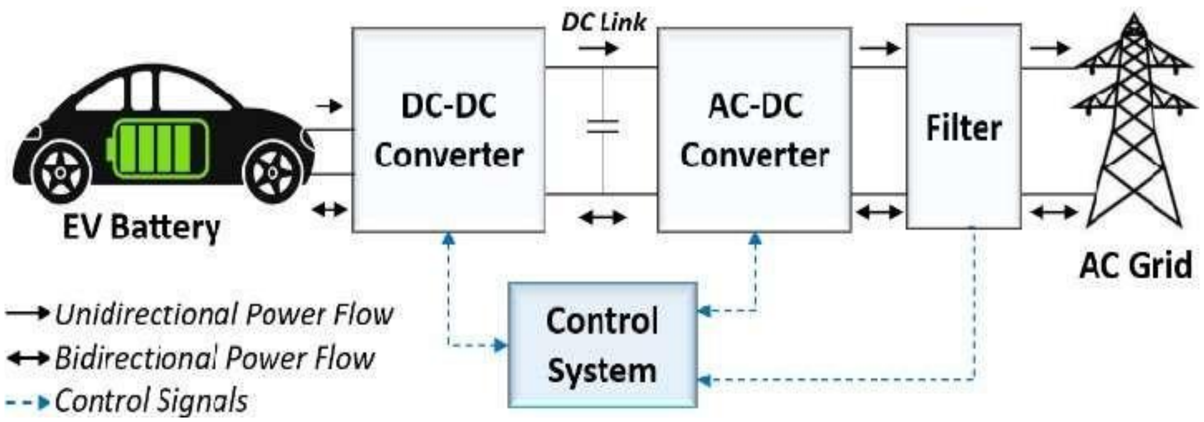

Figure 1: System Architecture EV Battery

Electric vehicle (EV) batteries are the main energy storage components that supply power to all electrical systems within an electric vehicle. These batteries store energy in chemical form and deliver it as direct current (DC) to drive the motor as well as auxiliary systems such as lighting, control units, and sensors. Among the various types, lithium-ion batteries are the most widely used due to their high energy density, lightweight nature, long lifespan, and fast charging capability.

DC-DC Converter:

A DC-DC converter is an essential power electronic device used to convert one level of direct current (DC) voltage into another level suitable for different applications. In electric vehicles, DC-DC converters play a crucial role in regulating and distributing power from the battery to various subsystems that require different voltage levels. These converters operate using high-frequency switching components such as MOSFETs, inductors, capacitors, and diodes to efficiently step up (boost), step down (buck), or both step up and step down (buck-boost) the input voltage

AC-DC Converter:

An AC-DC converter is a power electronic device that converts alternating current (AC) into direct current (DC), which is required for operating electronic systems and charging batteries. In electric vehicles, AC-DC converters are primarily used in onboard chargers, where AC power from the grid is converted into DC power to charge the EV battery. These converters typically consist of rectifier circuits, filters, and voltage regulation stages to ensure a smooth and stable DC output.

AC Grid:

The AC grid, or alternating current electrical grid, is the large-scale power distribution network that delivers electricity from power generation plants to homes, businesses, and electric vehicle charging stations. It typically provides AC voltage at standardized levels and frequencies, such as 230V/50Hz in many countries or 120V/60Hz in others. In the context of electric vehicles, the AC grid serves as the primary source of energy for charging the battery through an onboard AC-DC converter. EV chargers draw AC power from the grid, convert it into regulated DC, and safely deliver it to the battery pack. The AC grid also supports smart charging features, load management, and integration with renewable energy sources. Its reliability, voltage stability, and accessibility are critical for efficient and convenient EV charging infrastructure.

Conclusion:

The design and development of a Single Input Multi Output (SIMO) system for electric vehicles offers an efficient and compact solution for powering multiple subsystems from a single battery source. By integrating a DC-DC converter with a robust control strategy, the SIMO system can provide stable, regulated voltages to various loads such as controllers, sensors, and lighting, while minimizing energy losses and hardware complexity. The architecture reduces the need for multiple individual converters, improving overall system efficiency, reliability, and space utilization. With the support of advanced EV batteries and proper power management, the SIMO system enhances energy utilization and ensures safe operation under dynamic load conditions. Overall, such a system is a promising approach for modern electric vehicles, offering cost-effective, scalable, and high-performance power distribution for multiple outputs.

To conclude this project, complete design analysis, circuit diagrams and its working principles are elaborated. Thesis consists of the innovation introduced in this proposed project circuits, software and algorithms employed which include various power converter devices, and pulse shifting mechanism.

The SIMO system developed in this project addresses these critical challenges. By integrating a single EV battery with a multi-output DC-DC converter and a centralized control system, the SIMO architecture allows energy from the battery to be distributed efficiently to various loads. The system's design ensures that each output maintains a stable and regulated voltage regardless of variations in

load conditions or input voltage fluctuations. This is particularly important in electric vehicles, where dynamic load changes are common due to acceleration, regenerative braking, or operation of auxiliary systems like air conditioning, lighting, and infotainment.
EV batteries play a pivotal role in the success of the SIMO system. Lithium-ion batteries, which are the most common type used in modern EVs, offer high energy density, long life cycles, and fast charging capabilities. The battery pack acts as the single input source for the SIMO system, providing a stable DC voltage that can be efficiently converted to multiple output levels. The Battery Management System (BMS) monitors the health, state of charge, and temperature of the battery to ensure safe operation, protect against overcharging or deep discharge, and extend battery life. The integration of the SIMO converter with a high-performance battery ensures that the power supply remains stable and reliable across all operating conditions.
The SIMO system provides a scalable, high-performance solution suitable for modern electric vehicles of various sizes and power requirements. Its ability to reduce cost, weight, and space, while enhancing efficiency and reliability, makes it a promising approach for the next generation of EV power distribution systems. Overall, this project highlights the potential of SIMO technology to contribute significantly to the advancement of electric vehicle design, enabling smarter, greener, and more efficient transportation solutions.

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