ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24APR174

Design and Development of Controller for Electric Vehicle

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Abstract:- In this paper, we designing and developing controller and converter for the electric vehicles. In the electric vehicle battery is used as the energy source, by using of this battery operating electric motor. If we connect this battery direct to motor without any control device then it causes some unwanted problems in EV's. Because of the output voltage of battery is not suitable to operating Electric vehicles. Which means without any control mechanism the output voltage cannot be controlled and it will give divergence in output voltage in terms of error signal. Its result battery output power will reduce and therefore the performance of electric vehicle is go down in terms of power torque to drive vehicle. So in electric vehicle use of control mechanism is mandatory to control the output voltage of battery and that can achieve proper power and torque by a proper feedback control system. But price of the EV's are to much high higher the electric vehicle because of battery, motor and EV Controller.

Keywords:- Sensors, Motor, Microcontroller.

I. INTRODUCTION

Transportation is very important in for the development of a country. it enables the movement of people, goods and services. Which helps to growth of various sectors of economy. Road transportation is primary mode of transportation it consumes 88% sector of total transportation. To that transportation IC engine vehicles are used. Controller is used in EV's to control various actions of motor. A controller is a device that controls the speed, torque, direction, and power of an electric motor that drives an EV. It also enables the regenerative braking, which recovers some of the energy lost during braking. converter is also important part of EV it decrees or increase the voltage level according to required voltage rating. In EV different component are used which operate at low voltage rating and battery output voltage is high it will possible to damage components. therefore converter is used in EV's. But the cost of EV's is higher than IC engine vehicles because of cost of battery, motor and controller. In this paper we are representing the design and the development of EV controller and controller at cheaper cost and low weight.

➢ *Electrical Vehicle*

Electric vehicles are classified in to four main types:

Electric vehicles are classified based on the type of power source they use and the degree of electrification they have. There are four main types of electric vehicles:

- Battery electric vehicles (BEVs): These are fully powered by electricity and have no internal combustion engine or fuel tank. They rely on a large battery pack that can be charged by plugging into an external source of electricity.
- Plug-in hybrid electric vehicles (PHEVs): These use both an internal combustion engine and a battery-powered electric motor. The battery can be charged by plugging into an external source of electricity or by the engine. PHEVs can switch between electric and hybrid modes depending on the driving conditions.
- Hybrid electric vehicles (HEVs): These also use both an internal combustion engine and a battery-powered electric motor, but the battery cannot be charged externally. The engine is used to drive the vehicle and to charge the battery when it is low HEVs are more efficient than conventional vehicles, but less efficient than PHEVs or BEVs.
- Fuel cell electric vehicles (FCEVs): These use a fuel cell to generate electricity from hydrogen and oxygen. The only emission from FCEVs is water vapor. FCEVs have a high driving range and can be refueled quickly, but they are expensive and require a hydrogen infrastructure.

II. LITERATURE SURVEY

A. *Paper 1: "A Study on Recent DC-DC Converters" **Sidharth Sabyasachi, Mousumi Biswal's**.*

This paper presents a study on recent developments in dc-dc converters. All the converters are derived based on the two basic converters such as buck converter and boost converter. The aims of developing the converters are high efficiency and high gain with fast response. Research work has been grown dramatically to provide the service to the mankind.

B. *Paper 2: "Methods of Fast Analysis of DC–DC"- **Górecki, P.; Górecki, K.***

The paper discusses the methods of fast analysis of DC–DC converters dedicated to computer programs. Literature methods of such an analysis are presented, which determination of the characteristics of the considered converters in the steady state and in the transient states.

C. Paper 3: "DC-DC Converters for Electric Vehicles"- ***Joeri Van Mierlo ,Monzer Al Sakka,Hamid Gualous.***

DC-DC converters can be used to interface the elements in the electric power train by boosting or chopping the voltage levels Thus, in this chapter, a comparative study on three DC/DC converters topologies (Conventional step-up dc-dc converter, interleaved 4-channels step-up dc-dc converter with independent inductors and Full-Bridge stepup dc-dc converter) is carried out. The modeling and the control of each topology are presented.

D. Paper 4: "Controller Design for Electric Motor Derived Vehicle"- ***Degu Mena ,Nitin Kumar Saxena*** **.*

In this paper, proportional and integral based controller is designed for controlling the output voltage of battery. A PI based controller is designed and implemented for this electric motor derived vehicle in the present paper. Paper demonstrates how the results improve in presence of controller circuit for this electric motor derived vehicle.

➢ *Motor Controller*

In most of EV's BLDC motor is used a BLDC motor controller is a device that controls the speed and direction of a BLDC motor. A BLDC motor is a type of electric motor that does not have any brushes or commutators to transfer electricity to the spinning part. Instead, it uses magnets and coils to create motion.

The BLDC motor controller switches the electricity on and off in the windings in a specific sequence. This sequence makes the magnetic field of the stator change its direction and strength. The changing magnetic field attracts and repels the magnets on the rotor, making it spin. The controller can also adjust the amount of electricity in the windings to change the speed and torque of the motor.

The BLDC motor controller has some advantages over a brushed DC motor controller. It is more efficient, reliable, and durable because it does not have any mechanical parts that wear out sparks. It also produce less noise and heat.

III. PROPOSED SYSTEM

A. Problem Statement:

➢ *Control of Motor Speed:*

The speed of an electric vehicle (EV) is controlled by the vehicle's controller, which operates between the batteries and the motor. The controller simply regulate DC current flow for DC motors. The accelerator pedal sends a signal to the controller which adjusts the vehicle's speed by changing the frequency of the motor. Modern controllers adjust speed and acceleration by an electronic process called pulse width modulation.

This creates rotating magnetic fields that are always just ahead or just behind the poles of the motor, depending on the direction of motion. The controller also needs to synchronize the timing of the electrical currents with the position of the motor, which can be measured by sensors or estimated by algorithms.

➢ *Control of Battery Voltage*

The battery voltage in an electric vehicle (EV) is controlled by a battery management system (BMS), which is a device that monitors and regulates the state of the battery pack.

B. Block Diagram:

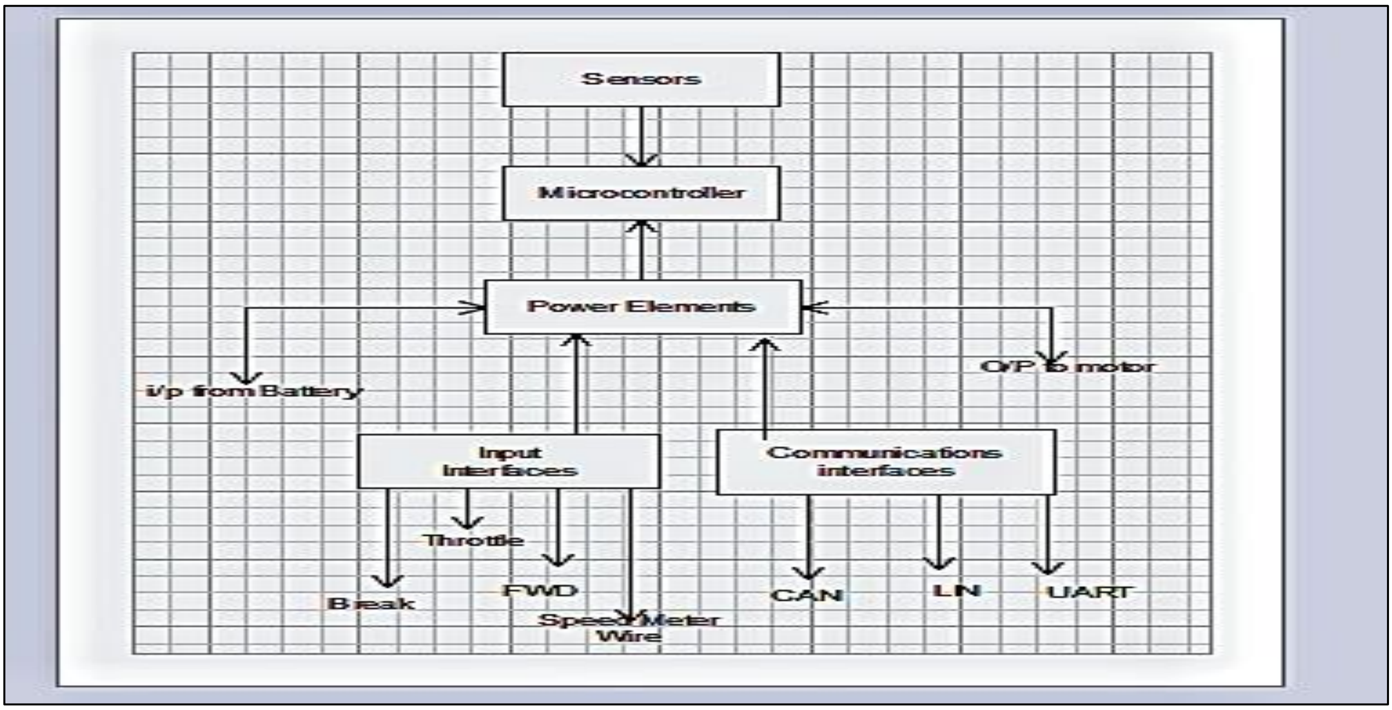

Fig 2: Block Diagram of Controller

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C. Hardware Requirement:

- Microprocessors
- CAN
- Motor speed sensor
- Battrey voltage sensor
- Throttle position sensor
- Breaking Sensor
- DC to DC Converter

D. Fundamental Steps for System

➢ *System Requirements Analysis:*

Define the electrical specifications of the electric vehicle system, including voltage levels, power ratings, efficiency targets, etc.

Identify the control and conversion requirements such as motor control, battery charging, power factor correction, etc.

➢ *System Modeling and Simulation:*

Develop mathematical models for individual components like motors, batteries, power electronics, etc., using circuit theory and electromechanical principles. Simulate the models using software tools like MATLAB/Simulink, PLECS, or LTspice to analyze the behavior of the system under different operating conditions.

➢ *Control Algorithm Design :*

Design control algorithms for motor drives, battery management systems, and power converters. Choose appropriate control techniques such as PI control, predictive control, or sliding mode control based on system requirements and performance criteria. Implement algorithms for tasks like torque control, speed regulation, current limiting, etc.

➢ *Converter Topology Selection and Design:*

Select suitable power converter topologies such as voltage source inverters (VSI), current source inverters (CSI), or buck-boost converters based on the application requirements. Design the converter circuits considering factors like efficiency, voltage/current ratings, switching frequency, and component stresses. Optimize the design for features like soft switching, high-frequency operation, and compactness.

➢ *Gate Drive and Protection Circuit Design:*

Design gate drive circuits to properly control the switching of power semiconductor devices (e.g., MOSFETs, IGBTs) in the converters. Implement protection features like overcurrent protection, overvoltage protection, and thermal protection to safeguard the converter and connected components.

➢ *Implementation and Hardware Integration:*

Implement the control algorithms and converter designs using microcontrollers, digital signal processors (DSPs), or FPGA-based platforms. Develop hardware interfaces for sensors, actuators, and communication buses to enable real-time control and monitoring. Integrate the control and converter hardware into the electric vehicle's powertrain system.

➢ *Testing and Validation:*

Conduct laboratory tests to verify the functionality, stability, and performance of the controller and converter under various operating conditions. Perform hardware-in-the-loop (HIL) simulations to validate the real-time behavior of the system. Ensure compliance with safety standards and regulations for electric vehicle components.

➢ *Deployment and Maintenance:*

Deploy the controller and converter systems in electric vehicles for field testing and real-world operation. Monitor system performance and reliability through diagnostics and data logging. Provide firmware updates and maintenance as needed to address issues and incorporate improvements.

IV. RESULT

➢ *Input Location*

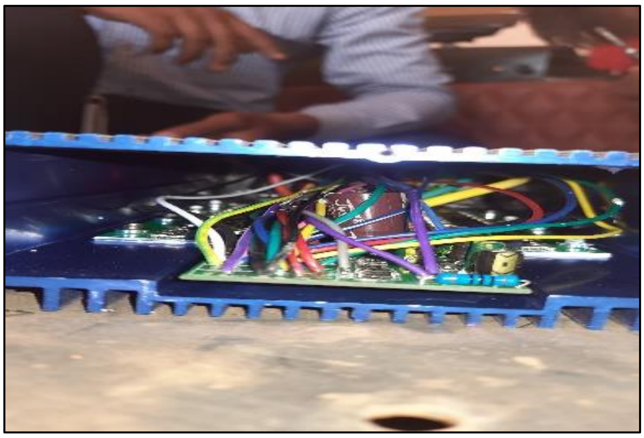

Fig 3: Input Page

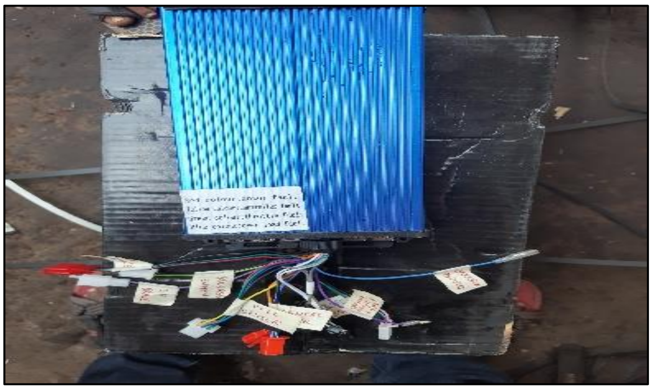

Fig 4: Output Page

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V. RESULT DISCUSSION

➢ *Protection Mechanisms. Discuss how the Performance Evaluation:*

Assess the performance of the controller and converter in terms of motor drive efficiency, battery charging efficiency, and overall system responsiveness. Discuss how well the control algorithms achieve desired objectives such as torque control, speed regulation, and battery management. Present experimental data or simulation results to illustrate the system's dynamic response under different operating conditions (e.g., acceleration, deceleration, steady-state driving).

➢ *Efficiency Analysis:*

Analyze the efficiency of power conversion processes within the system, including losses in the converter components (e.g., switching losses, conduction losses). Compare the efficiency of different converter topologies and control strategies to identify areas for optimization. Discuss the impact of efficiency improvements on the electric vehicle's overall energy consumption and driving range.

➢ *Stability and Robustness:*

Evaluate the stability and robustness of the control algorithms under various disturbances and uncertainties. Discuss the effectiveness of control strategies in maintaining system stability during transient events such as sudden load changes or voltage fluctuations. Present results from sensitivity analysis to assess the system's tolerance to parameter variations and external disturbances. Address the safety features implemented in the controller and converter design, such as fault detection, isolation, and system complies with relevant safety standards and regulations for electric vehicle components. Present reliability assessments, including mean time between failures (MTBF) calculations or failure mode and effects analysis (FMEA), to demonstrate the system's reliability in real-world applications.

➢ *Comparison with Requirements:*

Compare the achieved results with the initial design requirements and specifications. Discuss any deviations from the original requirements and the corresponding implications on system performance and functionality. Highlight areas where the system exceeds or falls short of the specified targets and provide recommendations for future improvements. Future Directions and Improvements Identify potential areas for further optimization and enhancement in the controller and converter design.

Discuss future research directions, such as exploring advanced control algorithms, optimizing power converter topologies, or integrating additional functionalities (e.g., vehicle-to-grid capabilities). Propose strategies for addressing emerging challenges in electric vehicle technology, such as increasing power density, improving energy efficiency, and enhancing system integration.

VI. CONCLUSION

In conclusion, the designing and development of EV controller and converter for electric vehicles is a challenging task that require the information about various component. The EV controller is responsible for controlling the speed, torque, direction, and power of the electric motor. It also support various modes of operations. The electric vehicle controller is a vital component for electric vehicles, as it regulates the speed and torque of the motor according to the driver's demand and the vehicle's operating conditions.

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