International Journal of Scientific Research and Engineering Development-– Volume 7 Issue 3, May-June 2024
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

AN ADAPTIVE CONTROL SYSTEM IN PLUG-IN-EV

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Abstract:

The energy management technique in plug-in electric vehicles (PEVs) is done by sliding mode control (SMC). SMC is applied to adjust the motor's torque while ensuring the motor speed remains constant. This strategy is crucial for enhancing the vehicle's battery life by improving energy utilization and efficiency. The SMC allows for more accurate control over the motor's torque, significantly benefiting the vehicle's energy management system. The goal of PEV energy management systems is to get the most mileage out of a single battery charge for the car. In order to maximize Plug-in Electric Vehicle performance, efficiency, and driving range while maintaining dependable and safe operation, energy management is essential.

Keywords **—**On-Load Tap Changers, Fuzzy Logic Controller, Gate Turn-Off Thyristors.

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I. INTRODUCTION

During past decades electric vehicles (EVs) have been gradually gaining popularity in the vehicle industry due to the various benefits they offer compared to their conventional counterparts. The vast majority of the vehicle manufacturers and many research organizations recommend the replacement of the conventional internal combustion engine (ICE) vehicles with EVs. Pure EVs that run slowlyon electricity eliminate the fossil fuel usage and consequently reduce the associate gas emissions. Additionally, their operation at low noise levels can highly reduce noise pollution, that adversely affect the life in urban areas. Therefore, it is evident that as the number of EVs entering the circulation increases, the overall transportation environmental footprint will be mitigated. The main environmental concern related to the difficulties in recycling the EV batteries seems to be overcome lately; there exist industries capable of fully recycling Lithium-ion (Li-ion) batteries, the type of batteries that the recent EVs make use.

Compared with other forms of machines PMSM are extensively applied because of features like improved dynamic performance, higher efficiency, smaller size, easy maintenance and so on.

Now a days PMSMs are widely used in home appliances and it has its application also in industries such as industrial robots, air-conditioners, wind-generation systems, electric vehicles, national defense, agriculture, washing machines and daily life. To control PMSM is not easy due to its nonlinearity feature. Presently, there are many methods available for controlling the torque, current and speed of the synchronous motors (like PMSM) which makes its application more in industries. [1,3]

The energy management system of electric vehicles encompasses several crucial functions, including cell balancing, which ensures that all battery cells maintain similar charge levels for optimal performance and longevity. Additionally, it safeguards against deep discharging and overcharging, which can harm battery components and pose safety risks. Through a combination of technologies and processes, these systems maximize the efficient and safe utilization of stored electrical energy. As technology advances, these systems evolve to become more sophisticated and effective, laying the groundwork for sustainable electric transportation in the future

.METHODOLOGY

In the Figure 1 the Block diagram explain that the Battery serves as theprimary power as the

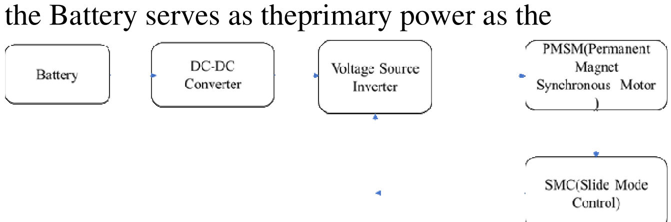

Figure 1: Block Diagram

source for the electric vehicle (EV). It storeselectrical energy in chemical form and supplies it to the rest of the EV system as needed, and convert one level of DC Current to Another level of DC Current.

The DC/DC converter plays a vital role in the electric vehicle's power system, transforming high-voltage DC battery power into lower voltage levels suitable for other electrical components. Its primary function is to ensure efficient power transfer and maintain stable voltage levels throughout the vehicle. The Voltage Source Inverter (VSI) is integral to the EV's powertrain, converting DC battery power into three-phase AC power necessary for driving the Permanent Magnet Synchronous Motor (PMSM) efficiently. As the primary propulsion system, the PMSM motor receives this AC power and converts it into mechanical energy to drive the vehicle. Known for their high efficiency and torque density, PMSM motors are crucial for achieving optimal vehicle performance. The Sliding Mode Control (SMC) algorithm serves as an advanced control system, continuously monitoring the motor's performance and adjusting parameters to ensure efficient operation. By dynamically regulating torque and speed, SMC enhances efficiency and stability while ensuring precise control. Acting as a closed-loop system, SMC receives feedback from the motor and adjusts VSI output accordingly, allowing for real-time optimization of motor operation and efficient energy management. This integrated approach optimizes motor performance and energy efficiency, ensuring smooth and reliable operation of the electric vehicle, by development of a robust controller for plug-in electric vehicles (PEVs) begins by providing essential background information on the significance of PEVs in addressing environmental concerns and reducing reliance on fossil fuels. It highlights the challenges faced by PEVs, such as limited driving range and the need for efficient energy management systems.So the energy management system implemented in plug-in electric vehicles (PEVs) focuses on optimizing vehicle performance and extending battery life by adjusting motor torque while keeping motor speed constant. This approach aims to improve energy efficiency by dynamically matching motor torque with the vehicle's energy demand, ensuring optimal operation without unnecessary energy consumption. By continuously monitoring energy needs and adjusting motor output accordingly, the system maximizes battery range and enhances vehicle performance across different driving conditions. The integration of sliding mode control (SMC) and load angle control provides a comprehensive control strategy, allowing precise adjustment of torque and flux to meet specific load requirements. This holistic approach ensures efficient energy utilization while maintaining vehicle performance and stability, ultimately contributing to a more sustainable and effective electric vehicle system.

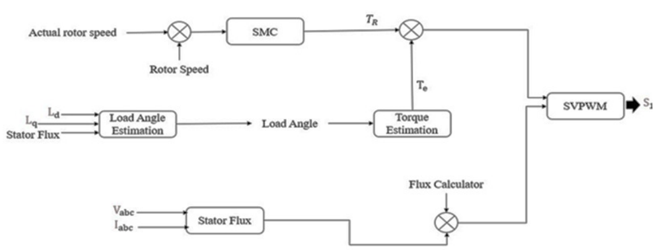

Figure 2: Control System Methodology

Here the Figure 2 explain that the actual speed and reference speed (1500 RPM) is compared were apply to SMC controller were SMC is the specific implementation details would depend on the characteristics of the motor and the requirements of the application. In here the rated speed of motor is kept to be constant and the change in system acceleration is caused by due to the torque variations and the torque is varied by proportion to the flux produced by the controller and also implying the Stator Flux,L_d,and $L_q$were Load Angle Estimation is nullify the Torque Estimation with Load Angle and compare the Rotor Torque $T_r$and Estimated TorqueT_e,The 3 phase Voltage and Current (V_{abc},I_{abc}) is also is compared with the Flux Calculator and apply to SVPWM ,were SVPWM It adjusts voltage applied to motor windings to ensure desired speed, optimizing energy efficiency and performance, crucial for smooth operation and adaptability to diverse driving conditions.

The performance and stability of plug-in electric vehicle (PEV) systems through the integration of various advanced control techniques. Central to this approach is the utilization of sliding mode control (SMC) and load angle control, which work in tandem to precisely regulate torque production and ensure efficient motor operation. By dynamically adjusting motor torque based on load angle and employing direct torque control (DTC), the system maintains stability and enhances overall efficiency. This comprehensive control strategy allows for adaptive and dynamic control adjustments, ensuring optimal performance across diverse operating conditions. Furthermore, the integration of renewable energy sources (RES) and electric vehicles (EVs) with the power grid represents a significant step towards sustainability, enabling the use of clean energy and promoting grid stability. Through advanced mechanisms for bidirectional power flow and grid interactions, this integration optimizes energy utilization while addressing practical constraints such as battery wear and user requirements. Ultimately, by adjusting motor torque to maintain constant RPM and maximizing energy efficiency.

III.PRINCIPLE OF OPERATION

Here the in the simulation the SMC controller plays a major role for controlling the Torque and speed, were the RPM speed is kept in Constant by Varying the Torque.

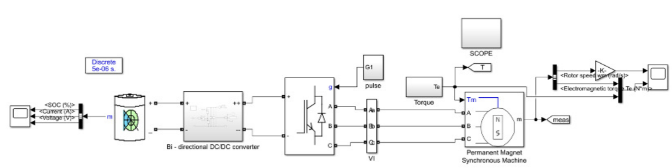

Figure 3: Simulation of Proposed System

SMC operates by establishing a sliding surface, compelling the system's state variables to remain on this surface during normal operation. This unique characteristic enables the controller to dynamically adjust system dynamics, providing robustness against disturbances and uncertainties. The torque adjustments are proportionate to the flux produced by the SMC, showcasing a dynamic and adaptive control strategy. Here the battery of 24 Ah were SOC,Current and Voltage are adjusted and given to Bidirectional DC/DC converter were converts a level of DC current to another level of DCcurrent and given to the Universal gate of Voltage source Inverter(VSI) were the another level of DC current is converter to 3 phase AC current wereused to rotate the PMSM motor .Here a pulse is used to trigger the Gate Pulse were SVPWM(strategyallowsto maintain efficiency and effectiveness across a range of operating conditions, contributing to the overall stability and performance of the electric machine) adjust the rotor speed by using SMC controller and control the torque and speed for the rotor .

□. RESULT AND DISCUSSION

At initially the motor is began to rotate in Constant speed by varying torque by SMC Controller. From 0-2 sec the motor will operate and rotate in 1500 RPM and settle downs to settled rpm. At that time the torque will have some fluctuations of +/- 50 and it began to stable in a linear way by SMC Controller.

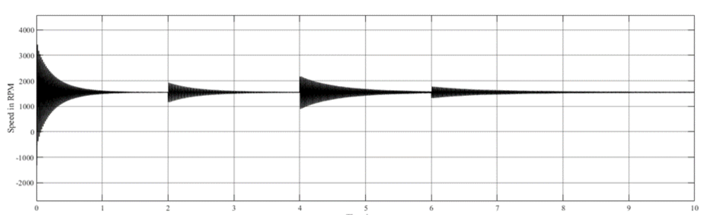

Figure 4: Speed changes with respect to time

At time 2-4 we decelerate the vehicle and torque will increase to 50 Nm i.e.; torque is inversely proportional to speed.

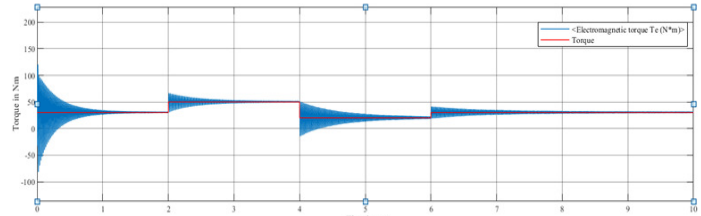

Figure 5: Torque changes with respect to time

At that time the SMC will control the system parameters and stabilises the motor rpm. When the vehicle speed is increased then the torque will reduce then the SMC will control the motor parameters and settles the motor rpm in linear way without any changes

□. CONCLUSION

The combination of renewable energy sources (RES) and electric vehicles (EVs) with the power grid marks a significant move toward sustainable energy practices. This integration supports the use of clean energy and enables complex interactions within the energy system, promoting a shift to a greener and more efficient infrastructure. It involves advanced mechanisms to handle the two-way power flow and interactions within the grid, enhancing stability and reducing energy wastage. This setup not only addresses environmental concerns but also adapts to practical limitations like battery wear and user needs, ensuring the solution is economically and socially sustainable. Adjusting motor torque to maintain constant RPM optimizes energy use and increases battery range, demonstrating the critical role of adaptive control in maximizing efficiency and supporting sustainable energy transitions.

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