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Effective Control of Speed and Regenerative Braking in Electric Vehicles Utilizing Fractional Order PI Controller

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Abstract:
In the automotive industry, a significant application of the Proportional Integral (PI) controller is in electric motors, specifically Brushless Direct Current (BLDC) motors used in Electric Vehicles (EVs). The accuracy of speed regulation in BLDC motors, acclaimed for their effectiveness and dependability, is crucial for enhancing vehicle performance and ensuring energy efficiency. On the other hand, regenerative braking is also important for energy recovery during vehicle navigation. In this paper, fractional order PI controller (FOPI) is implemented for smooth and precise control of speed and energy recovery during regenerative braking. Conventional Ziegler-Nichols method is used to tune the gains of the controller and for better controlling λ value for fractional order PI is predicted using trial and error method over extensive simulations on Simulink environment. The simulation results show accurate control of speed by variation of desired speed from 1500 rpm to 2800 rpm with fast transient response and without any delay. Energy recovery has been implemented through regenerative braking and show the battery charging and reverse flow of current during deceleration and applied braking in the EV.

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***Abstract*— In the automotive industry, a significant application of the Proportional Integral (PI) controller is in electric motors, specifically Brushless Direct Current (BLDC) motors used in Electric Vehicles (EVs). The accuracy of speed regulation in BLDC motors, acclaimed for their effectiveness and dependability, is crucial for enhancing vehicle performance and ensuring energy efficiency. On the other hand, regenerative braking is also important for energy recovery during vehicle navigation. In this paper, fractional order PI controller (FOPI) is implemented for smooth and precise control of speed and energy recovery during regenerative braking. Conventional Ziegler-Nichols method is used to tune the gains of the controller and for better controlling λ value for fractional order PI is predicted using trial and error method over extensive simulations on Simulink environment. The simulation results show accurate control of speed by variation of desired speed from 1500 rpm to 2800 rpm with fast transient response and without any delay. Energy recovery has been implemented through regenerative braking and show the battery charging and reverse flow of current during deceleration and applied braking in the EV.**

Keywords*— Electric Vehicles, BLDC motor, FOPI controller, Regenerative braking, Speed Control, Battery SOC

I. INTRODUCTION

Electric vehicles (EVs) have been developed to meet societal needs, thanks to technological advancements. There will be reduced pollution and a reduced likelihood of combustion engines in favour of electric vehicles. This has led to it being regarded as an urgent matter that is currently receiving a lot of attention. The accessibility of charging stations is the main concern regarding electric vehicles. For safety reasons, it is important to update the battery health status frequently, and the velocity control could use some work.

Secondly, in order to decrease charging period and ease range anxiety, electric vehicles must have fast charging technology. Examine the process for fast charging EVs, which calls for routine tuning of the DC-DC converters. An optimized proportional-integral (PI) controller and a control module monitor the state of charge (SOC) of the battery pack [1, 2]. Isolating, unidirectional, and bidirectional chargers with safety features are some of the types of electric vehicle charging that are discussed in the article [3]. Take a look at some complex charging concepts and setups, like the bidirectional isolated dual active bridge charger and the unidirectional full-bridge series resonant charger [4]. The amount of time it takes to charge is controlled by various electronic power converters. Interleaved DC-DC converter designs, Quasi Z sources, and multilayer inverters are becoming more popular for these schemes [5]. Electric vehicle charging infrastructure has been improved by battery swapping technology, which has reduced charging time [6]. Intelligent transportation systems are required by electric vehicle (EV) technology to monitor EV charging levels in smart cities, as stated in [7]. Addressing future charging challenges in the development of autonomous electric vehicles (EVs) can be achieved through the transmission of traffic data using V2V or V2G communication.

According to [8], one way to lower the costs of the electric vehicle (EV) subsystem is to use magnet-less motors instead of magnet motors. Magnet motors used in electric vehicles are either permanent magnet synchronous motors (PMSM) or high-efficiency brushless direct current (BLDC). It is vulnerable to demagnetization and expensive rare earth minerals [9]. The induction and switching reluctance motors of the future, which do not require magnets, make use of cheap materials. Troublesome issues with electric vehicle (EV) applications include torque ripple, noise in switching reluctance motors (SRM), and losses in induction motors (IM) [10].

It is possible for a Battery Management System (BMS) to run reliably and safely if it is well-designed. In addition, critical tasks that greatly impact the accuracy of State of Charge (SOC) include data updates, regulation of battery voltage balance, and defect identification. The SOC of a battery management system is taken into account, along with other important issues that have been recently assessed. In an internal combustion engine vehicle, the fuel gauge shows the amount of gas left in the tank, and in a similar vein, the State of Charge (SOC) of the battery controls this feature. An in-depth analysis of the charge states provides information about the battery's current and available performance and ensures the electric vehicle's safe and reliable operation. (11, 12). It is critical to monitor the SOC of the battery pack to avoid overcharging or undercharging it, which can damage the battery or reduce its performance. Voltage and current

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