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SPEED CONTROL OF BLDC MOTOR USING PI CONTROLLER IN ELECTRIC VEHICLE

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ABSTRACT :

The Brushless DC (BLDC) motor is extensively utilized in contemporary industrial and automotive applications owing to its superior efficiency, dependability, and minimal maintenance needs. This research focuses on controlling the speed of a BLDC motor with electrical commutation and advanced control techniques. The motor speed is controlled by altering the DC connection voltage or utilizing Pulse Width Modulation (PWM) via an inverter circuit. A microcontroller is used to monitor the rotor position via Hall sensors and provide the necessary switching signals for the inverter. The technology provides smooth and precise speed control while reducing torque ripple and improving dynamic performance. Simulation and experimental results show that the suggested control system is highly efficient, responsive, and stable across a wide range of speeds. This method makes BLDC motors ideal for electric vehicles, robotics, and industrial automation applications. Simulation is used to examine the performance of the proposed control system, which is then verified using hardware implementation. The results show that the BLDC motor has high efficiency, quick dynamic response, low torque ripple, and steady speed performance. Because of these features, BLDC motors are increasingly employed in electric vehicles, industrial automation, robotics, and domestic appliances, where efficient and precise motor control is required.

Keywords: Speed Control, Pulse Width Modulation (PWM), Electronic Commutation, Hall-effect Sensors, Microcontroller, Inverter Circuit.

INTRODUCTION

Brushless DC (BLDC) motors are a popular choice in current electrical drive systems due to their high efficiency, small size, and good speed-torque performance. The lack of brushes and mechanical commutators reduces problems like as sparking and wear, making BLDC motors extremely dependable and maintenance-free. This project describes the design and implementation of a speed control system for a BLDC motor that employs electronic commutation and pulse width modulation (PWM) control techniques. The speed is controlled by altering the duty cycle of the PWM signals sent to the inverter circuit, which powers the BLDC motor. Hall-effect sensors detect rotor position, and a microcontroller interprets the signals to provide accurate switching pulses for smooth operation. The system is intended to maintain a steady speed under varying load conditions while also providing fast dynamic response and little torque ripple. Simulation and experimental validation demonstrate that the proposed control approach is very efficient, stable, and responds quickly to speed fluctuations. The created system has potential applications in electric vehicles, robotics, industrial automation, and domestic appliances where precise and efficient speed control is required. This project focuses on controlling the speed of a BLDC motor via a microcontroller-based Pulse Width Modulation (PWM) approach. The PWM method is used to adjust the applied voltage, which efficiently controls the motor speed.

LIERATURE REVIEW

Haque, Md. Rezanul, and Shahriar Khan (2022) proposed a Modified Proportional-Integral (MPI) controller for BLDC motor-based electric vehicles, improving speed control accuracy, minimizing overshoot, and enhancing system stability and efficiency [1]. Rani, Yashi; Nangia, Uma; Jain, Narender Kumar (2023) explored the implementation of Particle Swarm Optimization (PSO)-based controllers for the speed control of a BLDC motor, achieving improved convergence, reduced overshoot and enhanced stability compared to traditional control methods [2]. Shah, Pranav; Ubare, Pramod Raghunath (2021) implemented a sensor less Sliding Mode Control with an observer for BLDC speed regulation using back-EMF zero-crossing; reported improved disturbance rejection, faster recovery, and reduced overshoot [3]. Suganthi, P. Nagapavithra , S. Umamaheswari, S. (2017) modeled and simulated a closed-loop PID-based speed-control system for a BLDC motor, showing improved stability, reduced steady-state error, and effective performance in MATLAB/Simulink simulations [4]. Suryoatmojo, H. Cladella, F. G. Lystianingrum, V. Riawan, D. C. Mardiyanto, R.; Ariana, D. (2018) proposed a hysteresis-current-control scheme implemented with a Bridgeless Isolated Ćuk (BIC) converter for BLDC speed control, improving power factor, reducing current/torque ripple, and enhancing transient response [5].

METHODOLOGY

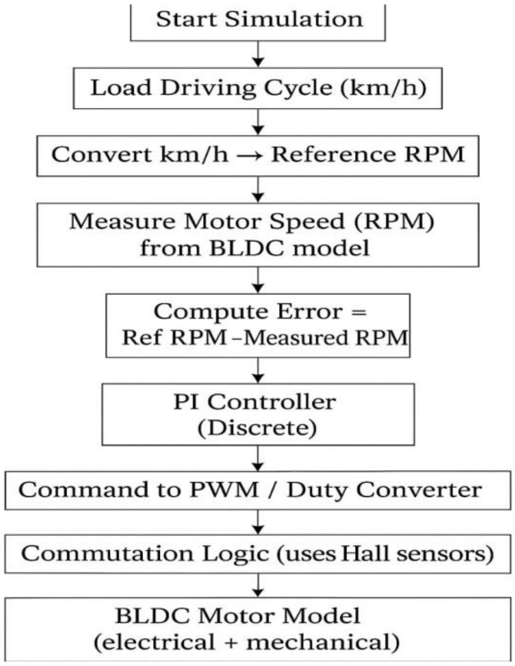

Figure 1: Methodology

The flowchart depicts the method for controlling the speed of a BLDC motor in a simulated environment with a PI controller. The procedure begins with beginning the simulation and loading the driving cycle, which provides the desired vehicle speed in km/h over time. This speed is then translated into an equivalent reference RPM, which is used as the goal speed for the BLDC motor. The motor model uses sensor feedback to continuously measure the real speed (RPM). The error between the reference and actual speeds is then determined. This error signal is analyzed by the Proportional-Integral (PI) controller, which modifies the control output to reduce deviation and achieve steady speed operation. The output of the PI controller is sent to a PWM or duty cycle converter, which generates appropriate switching signals to control the inverter supplying the motor. The commutation logic, driven by Hall sensor signals, ensures that the inverter switches are triggered in the correct sequence to maintain smooth rotation of the motor. Finally, the BLDC motor model, which includes both electrical and mechanical dynamics, responds to these control signals, and the feedback is used to continuously regulate the motor speed. This closed-loop system ensures accurate, stable, and efficient speed control of the BLDC motor under various load and speed conditions.

RESULTS

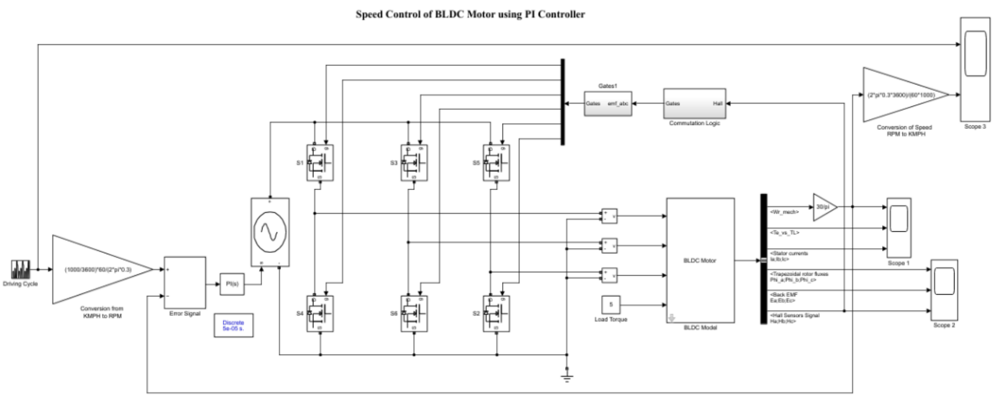

Figure 2 : Simulation model

The block diagram below depicts a Simulink model for speed control of a Brushless DC (BLDC) motor using a Proportional-Integral (PI) controller. The system starts with a driving cycle input that specifies the reference vehicle speed in km/h. This speed is then converted to motor speed in RPM using a conversion block that takes into consideration the wheel radius and gear ratio. The reference RPM is compared to the actual motor speed calculated using the BLDC motor model, and the difference (error signal) is given to the PI controller. The PI controller produces a control output voltage proportionate to the speed error, which governs the Pulse Width Modulation (PWM) signals that power the three-phase inverter.

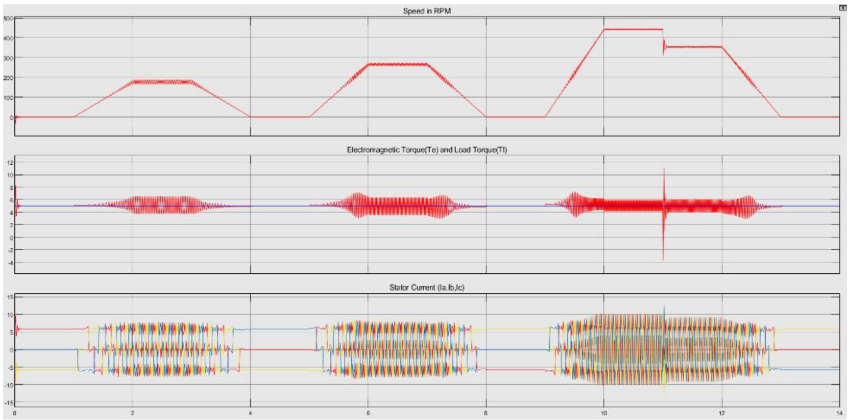

Figure 3 : Speed, Electromagnetic Torque, Stator Current graphs

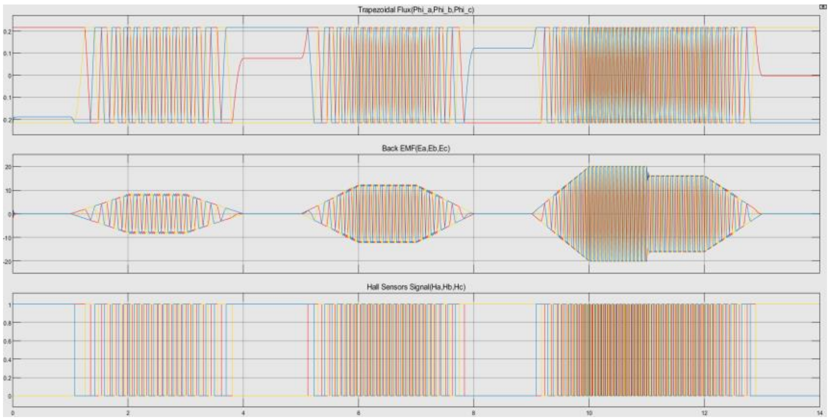

Figure 4 : Trapezoidal Flux , Back EMF , Hall Sensors

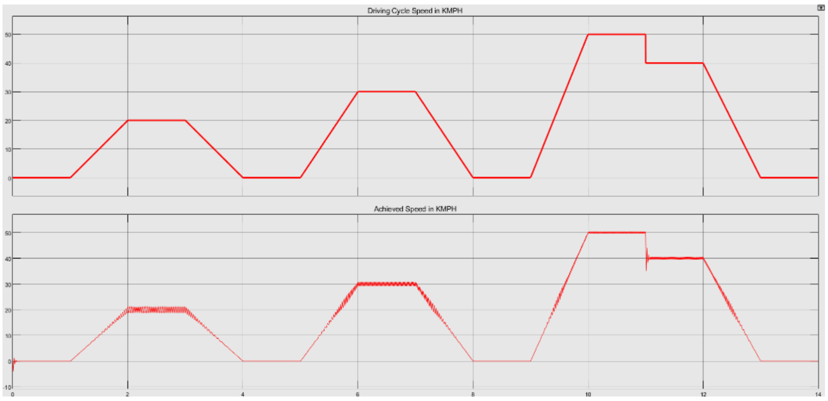

Figure 5 : Achieved Speed, Driving Cycle Speed

The scope plots illustrate the performance of a Brushless DC (BLDC) motor drive following a demanding driving cycle up to 50 KMPH. The system effectively tracks the reference speed, achieving a peak of 400 RPM demonstrating good speed control. The motor operates in three distinct phases, with the highest demand occurring around the 10 to 13 second mark, resulting in peak Back EMF and stator current amplitude. The plots confirm the use of six-step (trapezoidal) commutation, as evidenced by the high-frequency square wave output of the Hall sensors and the characteristic current/torque ripple during active driving periods. The increasing frequency of the Hall signals correctly reflects the rising motor speed.

CONCLUSION

The study on speed control of a brushless DC (BLDC) motor shows that modern electronic and control approaches such as pulse width modulation (PWM) and microcontroller-based systems can be used to provide efficient motor speed management. The use of electronic commutation reduces the mechanical losses associated with brushes, resulting in increased efficiency, lower noise, and longer motor life.Under variable load circumstances, the developed system delivers precise and smooth speed regulation, rapid dynamic response, and decreased torque ripples. Simulation and experimental results demonstrate that by altering the duty cycle of the PWM signal, precise control of motor speed may be achieved without sacrificing performance. The integration of Hall-effect sensors and a suitable control algorithm guarantees that the drive system operates reliably and is stable. The project emphasizes the benefits of BLDC motors over traditional motors in terms of efficiency, dependability, and controllability. Such speed control systems can be efficiently used in electric vehicles, robotics, industrial automation, and renewable energy systems, helping to advance energy-efficient and sustainable motion control technologies. The speed control of BLDC motors assures excellent efficiency, smooth operation, and rapid dynamic response, making them perfect for electric vehicles, automation, and energy-efficient driving applications.

REFERENCES

1. Suryoatmojo, H., et al. "Performance of BLDC Motor Speed Control Based on Hysteresis Current Control Mechanism: IEEE." *IEEE*, Aug. 2018, pp. 147–52. https://doi.org/10.1109/isitia.2018.8710910.
2. Rani, Yashi, et al. "Implementation of PSO based Controllers for Speed Control of BLDC Motor: IEEE." *IEEE*, May 2023, https://doi.org/10.1109/incet57972.2023.10170535.
3. Aghaee, Marziyeh, and Ali Akbar Jalali. "BLDC Motor Speed Control Based on MPC Sliding Mode Multi-Loop Control Strategy – Implementation on Matlab and Arduino Software: IEEE." *IEEE*, May 2018, pp. 795–800. https://doi.org/10.1109/icee.2018.8472464.
4. Kumar, Abhishek, et al. "Comparative Analysis of Speed Control for BLDC Motors in Electric Two-Wheeler Applications: IEEE." *IEEE*, May 2025, pp. 1–6. https://doi.org/10.1109/ic2e365635.2025.11167351.
5. Suganthi, P., et al. "Modeling and simulation of closed loop speed control for BLDC motor: IEEE." *IEEE*, Mar. 2017, pp. 229–33. https://doi.org/10.1109/icedss.2017.8073686.
6. Anitha, E., and P. Vairaprakash. "Design of dynamic states and digital speed control of BLDC motor: IEEE." *IEEE*, vol. 25, Mar. 2016, pp. 1–6. https://doi.org/10.1109/iccpct.2016.7530313.
7. L, Niveda, et al. "Speed Control of BLDC Motor Using Six-Step Commutation: IEEE." *IEEE*, Aug. 2025, pp. 592–96. https://doi.org/10.1109/icees67011.2025.11213203.
8. Gupta, Gopal, and Mini Sreejeth. "Comparative Analysis of Speed Control of BLDC Motor Using PWM and Current Control Techniques." *2022 IEEE IAS Global Conference on Emerging Technologies (GlobConET)*, May 2022, pp. 610–14. https://doi.org/10.1109/globconet53749.2022.9872173.
9. Awaar, Vinay Kumar, et al. "Comparative Study and Experimentation of Speed Control Methods of BLDC Motor Using DRV8312." *2022 IEEE 2nd International Conference on Sustainable Energy and Future Electric Transportation (SeFeT)*, vol. 25, Aug. 2022, pp. 1–6. https://doi.org/10.1109/sefet55524.2022.9909121.
10. Poornesh, Kavuri, et al. "Speed Control of BLDC motor using Fuzzy Logic Algorithm for Low Cost Electric Vehicle: IEEE." *IEEE*, Aug. 2022, pp. 313–18. https://doi.org/10.1109/icistsd55159.2022.10010397.
11. Aspalli, M. S., et al. "Speed control of BLDC motor with Four Switch Three Phase Inverter using Digital Signal Controller: IEEE." *IEEE*, Aug. 2015, pp. 371–76. https://doi.org/10.1109/icpace.2015.7274975.
12. Alqarni, Zuhair. "Higher Order Sliding Mode Control for Speed Control of BLDC Motor." *2022 IEEE 12th Annual Computing and Communication Workshop and Conference (CCWC)*, Mar. 2023, pp. 0212–17. https://doi.org/10.1109/ccwc57344.2023.10099280.
13. Walekar, Vaishali Rajendra, and S. V. Murkute. "Speed Control of BLDC Motor using PI and Fuzzy Approach: A Comparative Study: IEEE." *IEEE*, Aug. 2018, pp. 1–4. https://doi.org/10.1109/icicet.2018.8533723.