International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

BLDC Motor Speed Control with PID Controller in Electric Vehicles

Dr Trupti V N[1], Assistant Professor,
Department of Electrical & Electronics Engineering,
Jain (Deemed-to-be) University,
Bangalore, India
n.trupti@jainuniversity.ac.in

Mr Md Firuz Mia[2], UG Student,
Department of Electrical & Electronics Engineering,
Jain (Deemed-to-be) University,
Bangalore, India
firuzbddh@gmail.com

Mr Md Asim Akram[3], UG Student,
Department of Electrical & Electronics Engineering,
Jain (Deemed-to-be) University,
Bangalore, India
asim.akram726@gmail.com

Abstract

This paper demonstrates that BLDC motors are the best motors for various electric vehicle control strategies. Synchronous motors are the group that includes BLDC motors. Future transportation is interested in electric vehicles because of their zero emissions, sustainability, efficiency, and variety of control methods. These motors are the best option for many applications; however, the majority of them need sensor-less control. Rotor-position sensing is necessary for BLDC motors operating in order to regulate the winding currents. A BLDC motor drive's speed can be controlled via sensor-less control, digital signal controllers, digital signal processors, fuzzy logic PI controllers, PID controllers, adaptive neuro-fuzzy controllers, genetic algorithm controllers, and other methods. The overarching goal of this research is to provide a simulation of the PID controller approach for BLDC motors in electric vehicles.

Keywords: BLDC Motor, sensor, controller, sustainability

I. Introduction

The modern era is dependent on technology, and by utilizing this technology, we can create many forms of electric vehicles. This electric car employs a variety of motor technologies. BLDC motors are one of them. Primary efficiency is the most essential attribute of BLDC motors. In a BLDC motor, the current-carrying wire is stationary while the permanent magnet moves. Because the rotor is the sole carrier of the magnets and requires no power. In other words, there are no linkages in commentators, or brushes. In place of them, the motor uses control circuits. BLDC motors use controllers, rotary encoders, or Hall sensors to determine where the rotor is at any given time. A BLDC motor operates on a similar concept as a BLDC motor. The standard scheme for BLDC motor ontology, power drives circuits, and position sensors. BLDCM is typically used with 3-phase state PWM.

Fig.1: BLDC Motor

An engineer is constantly thinking about how to improve or develop technology. There are several different control techniques for BLDC motors in electric vehicles. Control experts employ PID (proportional-integral-derivative) controllers to regulate temperature, flow, pressure, speed, and other process parameters in industrial control systems. PID controllers are becoming more significant in electric vehicles. The three-phase BLDC speed control system uses both open and closed-loop designs. Open-loop control manages the motor's speed by directly modifying the duty cycle of the PWM signal that powers the motor-drive electronics.

II. Literature Review

"Control Method of Sensor less Brushless DC Motor Based on Neural Network" in this study, the primary idea of position sensor less control techniques is to eliminate the position sensors.

The article, "PI Controller for BLDC Motors Considering Variable Sampling Effect," attempts to

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

PID method, or command, is an extremely common and pro minent controller. It is used to increase the device's adaptability.

"Regenerative Braking System of an Electric Vehicle Driven by a Brushless DC Motor" Takahashi and Noguchi proposed direct torque control (DTC) for induction motors in 1986, followed by Depend Brock in 1988. Many recent studies have focused on the DTC of BLDC motors for specialized applications requiring fine torque control.

"Direct torque control of brushless DC motor with non-sinusoidal back-EMF" proposes to apply the DTC technology of BLDC to the drive train of a hybrid electric car.

"Speed Control of BLDC Motor Using Neural Network Controller and PID Controller", the purpose of this research is to control the speed of a brushless DC motor using an artificial neural network (ANN) controller and a PID controller.

"Review on Exponential Growth of Different Controllers for Brushless DC Motor", this study investigates several methods for controlling the speed of BLDC motors using sophisticated controllers.

"Adaptive PID Controller Using for Speed Control of the BLDC Motor", in this study, adaptive PID controllers rely on the extra error of the reverse control signal being appropriate for the next movement, while the influence of parameter changes is reduced.

"A Review of Modeling, Analysis and Control Methods of Brushless DC Motors", the paper analyzes numerous ways of modeling and analyzing BLDC motors, including control schemes.

"Improved Electric Differential System for Independent Speed Control of Brushless DC Motors Driven Electric Vehicles", this research provides an improved electric differential system (EDS) for an electric vehicle (EV) that controls two front wheels separately using brushless DC (BLDC) motors and resilient fuzzy logic speed controllers.

III. Constructional Features of BLDC Motor

BLDC motors, additionally referred to as electronically commutated motors, are synchronous motors that operate on DC electricity via an inverter or switching power source. A closed-loop controller creates an alternating current (AC) current to power each phase of the motor. The controller sends electric current pulses to the motor's armature windings, regulating its speed and torque.

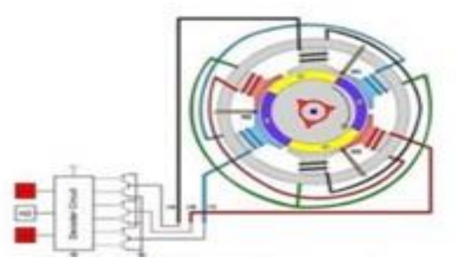

Fig.2: BLDC Motor Winding Connection

An electronic drive drives the brushless DC motor by switching the supply voltage between the stator windings as it turns. The optical or magnetic transducer detects the position of the rotor and transmits data to the electronic controller. The electronic controller then utilizes this location to determine which stator windings should be energized.

IV. PID Control Strategy

A BLDC motor cannot be controlled or its speed cannot be observed without a controller circuit. Numerous controller speed control systems exist; however, over time, the controls must be adjusted. Nonetheless, control systems are typically categorized as either closed-loop or open-loop. Closed-loop approaches are employed for devices with high precision control.

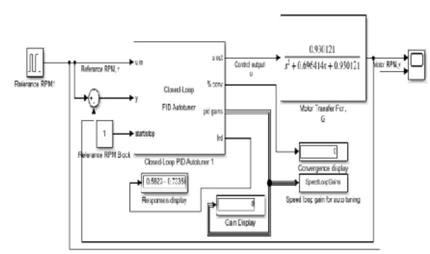

Fig.3: The block diagram for PID control

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

The graphic depicts a PID speed controller diagram that uses closed-loop systems. The PID auto-tuner algorithm or control is the most well-known and widely used controller. It is used to expand the device's capabilities. PID requires human configuration, but the auto-tuner technique automatically adjusts for the PID variable component, despite the fact that the two methods are similar.

V. Modeling of controlling the speed of BLDC Motor using PID controller

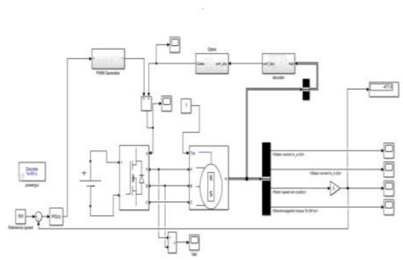

Fig.4: Modeling of controlling the speed of BLDC Motor using PID controller

- **Speed Input:** The system starts with a reference speed input (500), which determines the required speed for the BLDC motor.
- **PID Controller:** The reference speed is compared to the actual rotor speed, and the difference is supplied into a PID (proportional-integral-Derivative) controller (PID (z)). The PID controller modifies the control signal to reduce speed errors and achieve the target motor speed.
- **PWM Generator:** The PID controller's output is sent into a PWM generator. PWM controls the voltage and current provided to the motor windings by switching the power transistors on and off at high frequencies.
- **Motor:** The BLDC motor is linked to the inverter through three phases (A, B, and C). The inverter controls the motor's functioning by applying suitable voltages to these phases, depending on PWM signals.
- **Measurement and Display:**
  The measured data (stator currents, rotor speed, and elec tromagnetic torque) are displayed or recorded for purpo ses of monitoring.

Subsystem of the simulation:

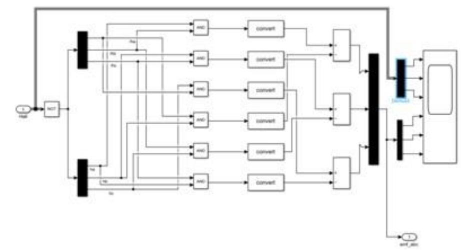

Fig.5: Decoder block

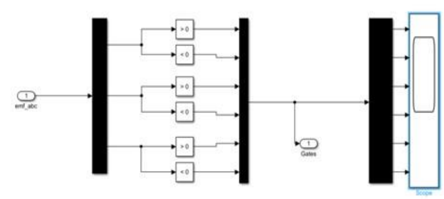

Fig.6: Gate block

- **Gates and Decoder:** The PWM generator powers the gates of a power electronic converter (often an inverter). The inverter turns the power supply's DC power into AC power, which drives the motor. The "Gates" block represents the gate signals used by the inverter's transistors. The "decoder" block decodes feedback signals such as back EMF and Hall sensor signals to provide location and speed information for the rotor.

VI. Result

The x-axis frequently indicates time, which shows how the variable evolves over time. The y-axis shows the magnitude of the variable being measured. At the start of the figure, the variable changes abruptly, indicating a transitory response.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

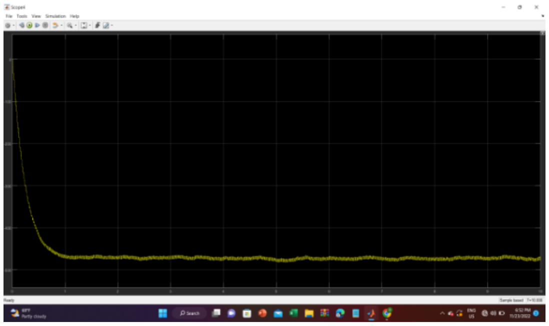

Fig.7: Torque output

This is typical in systems that have undergone a quick shift, such as a step input or an initial state. After the first transient, the variable gradually stabilizes and settles to a consistent value. This portion of the plot depicts the system achieving a steady state.

Fig.8: Stator current

The persistent oscillations could indicate that the PID controller is not effectively calibrated. High-amplitude oscillations indicate either over tuning (high gain values) or insufficient dampening (low derivative gain). The noise in the signal could be the result of external disturbances or intrinsic noise in the system under control. This could potentially indicate the system's susceptibility to such perturbations.

VII. Conclusion

The application of a PID control method for brushless DC (BLDC) motors in electric vehicles (EVs) offers a highly effective method to managing motor performance and ensuring smooth, dependable operation. The PID controller regulates the motor's torque output, providing benefits and addressing problems in EV applications. The PID controller precisely controls the BLDC motor, minimizing error and obtaining specified performance metrics. This improves vehicle stability, acceleration, and general drivability. By constantly altering the motor's input settings, the PID controller ensures optimal torque output while responding to changing load situations and operating scenarios. This optimizes power utilization and improves the driving experience. Proper tuning of PID parameters decreases oscillations and noise in motor performance. This results in quieter operation and reduced mechanical wear, increasing the motor's life and boosting passenger comfort. The PID control strategy is robust and adaptive to a variety of operating circumstances, including changing speeds and loads. This versatility is critical for EVs, which must operate in a variety of driving conditions while maintaining constant performance. The PID control approach is critical to improving the functionality and efficiency of BLDC motors in electric cars. Its capacity to provide accurate, adaptive, and dependable control makes it a critical component in the development of high-performance, energy-efficient, and user-friendly electric vehicles. As EV technologies develop, PID control solutions can boost motor performance and vehicle dynamics even further.

VIII. References

[1] E. C. Lee, “Application of brushless dc drives in blow molding,” 1993. Published by Po wertechIndustrial Motors.

[2] T. Kinjo and S.Nagamori, Permanent Magnet Brushless DC Motors, Clarendon Press, oxford, 1985.

[3] J. M. D. Murphy and F. G. Turnbull, “Power Electronic Control of AC Motors”, Pergamon Press, Oxford, 1988.

[4] J. F. Gieras and M. Wing, Permanent Magnet Motor Technology – Design and Application, Marcel Dekker Inc.New York, 2002.

[5] Zhang Jinquan,Gudeying, “Control Method of Sensorless Brushless DC Motor Based on Neural Network”, The 26th Chinese Control and Decision Conference (2014 CCDC), IEEE Xplore 2014.

[6] Cheng-Tsung Lin, Chung-Wen Hung and Chih-Wen Liu, “Fuzzy P1 Controller for BLDC motors Considering

Variable Sampling Effect", The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON), Nov. 5-8, 2007, Taipei, Taiwan.

[7] Yusuf Karabacak, Ali Uysal, "Fuzzy Logic Controlled Brushless Direct Current Motor Drive Design and Application for Regenerative Braking", International Artificial Intelligence and Data Processing Symposium (IDAP), IEEE Xplore 2017.

[8] Xiaohong Nian, Fei Peng and Hang Zhang, "Regenerative Braking System of Electric Vehicle Driven by Brushless DC Motor", IEEE Transactions on Industrial Electronics, Vol. 61, No. 10, October 2014.

[9] Bo Long, Shin Teak Lim, Ji Hyoung Ryu and Kil To Chong, "Energy-Regenerative Braking Control of Electric Vehicles Using Three-Phase Brushless Direct-Current Motors", Energies 2014, 7, 99-114

[10] M. Depenbrock, "Direct self-control of inverter-fed induction machine" IEEE Transaction on Power Electron., vol. 3, no. 4, pp. 420–429, Oct. 1988.

[11] S.B. Ozturk, H.A. Toliyat, "Direct torque control of brushless dc motor with non-sinusoidal back-EMF", IEEE International Conference on Electric Machines & Drives, IEMDC 2007, Vol. 1 Pages 165 – 171

[12] M. Mahmud, S. M. A. Motakabber, A. H. M. Zahirul Alam & A. N. Nordin, "Control BLDC Motor Speed using PID Controller," International Journal of Advanced Computer Science and Applications (IJACSA), 11(3), 2020.

[13] R. I. Boby, K. Abdullah, A. Z. Jusoh, N. control system," Telkomnika Parveen and M. Mahmud, "Adaptive control of non-linear system based on QFT application to 3-DOF flight, 17(5), 2019.

[14] Archana Mamadapur, Dr.Unde Mahadev G., "Speed Control of BLDC Motor Using Neural Network Controller and PID Controller", 2nd International Conference on Power and Embedded Drive Control (ICPEDC), 2019.

[15] Diksha Dayanand Patil, Professor P. R. Jadhav, "Review on Exponential Growth of Different Controllers for Brushless DC Motor", Third International Conference on Computing Methodologies and Communication, 2019.

[16] Md Mahmud, S. M. A. Motakabber, A. H. M. Zahirul Alam, Anis Nurashikin Nordin, "Adaptive PID Controller Using for Speed Control of the BLDC Motor", IEEE International Conference on Semiconductor Electronics (ICSE), 2020.

[17] Adil Usman, Bhakti M Joshi, Bharat Singh Rajpurohit, "A Review of Modeling, Analysis and Control Methods of Brushless DCMotors",

International Conference on Computation of Power, Energy Information and Communication (ICCPEIC), 2016.

[18] Mohsen Ebadpour, Javad Tayefi Oujghaz, "Improved Electric Differential System for Independent Speed Control of Brushless DC Motors Driven Electric Vehicles", 7th International Conference on Control, Instrumentation and Automation (ICCIA), 2021