International Journal of Recent Advances in Multidisciplinary Topics
Volume 3, Issue 8, August 2022
https://www.ijramt.com | ISSN (Online): 2582-7839

Speed Control of BLDC Motor Using MATLAB/Simulink Environment

Luntan Vankiuba[1], Pranav Kumar Rowlo[2], Challa Harish[3], P. K. Dhal[4*]

[1,2,3]*B.Tech., Department of Electrical and Electronics Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India*

[4]*Professor, Department of Electrical and Electronics Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India*

***Abstract*: Electrically commutated brushless DC motors are brushless DC motors. The synchronous motor's speed and torque are controlled by the controller's current pulses, which are sent to the motor windings. An external permanent magnet motor, three-phase driving coils, and one or more Hall effect sensors to sense the position of the motor and the drive electronics make up a BLDC motor. BLDC motors are very efficient because a lot of torque is produced across a wide speed range. Permanent magnets don't require an electrical connection to the armature because they revolve around a stationary armature. Electronic transportation has a wide range of options and adaptability. The motor is renowned for its quiet operation and maintaining torque when it is stationary.**

***Keywords*: Permanent magnet, BLDC motor, torque, armature.**

1. Introduction

The increasing number of electronic devices depends heavily on electric motors. The designs of motors have been changing for almost a century. BLDC motors are built similarly to synchronous machines that use permanent magnets; however, they are descended from brushed DC motors. A BLDC motor can be as little as an instrument motor or as powerful as hundreds of kilowatts. Their use in electronics computer fans, CNC machines, and industrial robots is fairly widespread. Additionally, they are used in traction motors that power locomotives, trams, road vehicles, and electric bicycles. Due to its power density and compatibility with induction and reluctance motors, BLDC motors with permanent magnets are widely used. A BLDC motor also has the advantage of being lighter and more compact than a brush type while yet producing the same amount of power. The most common form of motor is three-phase, though one-two and three-phase versions are also available.

2. Literature Survey

According to Alasayid, "Uses of BLDC motors have expanded in recent times as a result of evaluation in the field of magnetic materials and power electronics, as well as the availability of cheap and powerful processors." [1]. According to Suganthi, many electrical devices are developed with permanent magnets rather than electromagnets since it has more advantages and they have minimal excitation loss, are cost-effective, and create high output torque [2].

According to Mohammed Ismail, huge permanent magnets were employed for excitation in the earlier 19th century, but in the 20th century, more potent magnets like Alcomax and Alnico were discovered, producing more magnetic field lines and establishing strong coercive force in the machine, because they have greater benefits than traditional DC motors, Kamal claimed that "BLDC motors are commonly used in Servo motor applications [3]. To control BLDC motors, a simpler current-controlled modulation technique is employed which is based on the creation of Quasi-square wave current, by employing only one current controller for three phases may control the motor, Dubey recommended. The phase currents are maintained in balance, and the current is only controlled by one DC component, among other benefits of this method [4][5]. According to P.S.Vikhe, BLDC motors offer good performance in both current and upcoming applications. These motors have a variety of uses, including spinning, drilling, elevators, locks, etc., and changing speed in BLDC motors is simple to implement [6]. According to Uma Gupta, BLDC motors are more efficient, consume less fuel, and have a higher power-to-volume ratio than other types of motors [7]. R.G.Rajesh proposed that BLDC motors should have torque smoothness for high performance and efficiency. It is more crucial to obtain a precise and ripple-free instantaneous torque for good control performance [8]. Due to their attributes like great dependability, a simple frame, high efficiency, quick dynamic response, compact size, and very little maintenance, BLDC motors are also frequently utilised for domestic applications, according to Sathish Kumar [9]. According to Juhi Nishat Ansari, brushed DC motors have various drawbacks that are solved by BLDC motors. Additionally, the motor can be effectively regulated by employing hall effect sensors [10].

3. Basic Concept of Open Loop Control and Closed Loop-Based BLDC Motor System

By altering the analogous conceptual brush position and shifting the sensor location relative to the motor frame, it is possible to control the open-loop speed of BLDC motors in a

*Corresponding author: pradyumna.dhal@rediffmail.com

manner similar to that of a connectional DC machine. Permanent magnet BLDC motors are widely used in industrial applications. When high torque is required for industrial application, they are crucial. The commutation parametrial is suitably selected in the open-loop. The motor will progressively pick up speed after selecting the right parameter, eventually operating in open-loop commutation mode at a constant speed. Electronic commutation of the BLDC motor is done in accordance with the motor position. Two of the three phases in each commutation sequence are related. PWMs can be used to control the average voltage delivered across the windings, which is utilized to control the speed, when the third phase of the power supply is left open.

The operational reference currents in the closed loop system are analogous to square waves. When in driving mode, they develop in phase with the back-emf and out of phase when in braking mode. The PI controller's output is controlled to provide the reference torque and to process the speed error signal before producing the torque within limits. To lessen the inaccuracy in deviating from the reference speed, the speed controller is utilized to feed back the motor's real speed for analysis. The result is that the entire system is a closed-loop control drive system.

4. Proposed MATLAB Model of Open Loop BLDC Motor System

The MATLAB model for an open-loop control system for the BLDC motor is depicted in the picture. A dc power source is switched to the motor's stator phase winding by a power device, and the entire switching sequence is based on the motor's location. The BLDC motor's phase current has a rectangular shape. This is then timed to provide consistent torque at a constant speed in conjunction with the back emf. The mechanical commutation is increased by using the electronic switch. This, depending on the motor position, conveys the appropriate to the motor winding. A hall signal is used to determine the motor position, and depending on that signal, inverter switches are switched off to create a constant rotation.

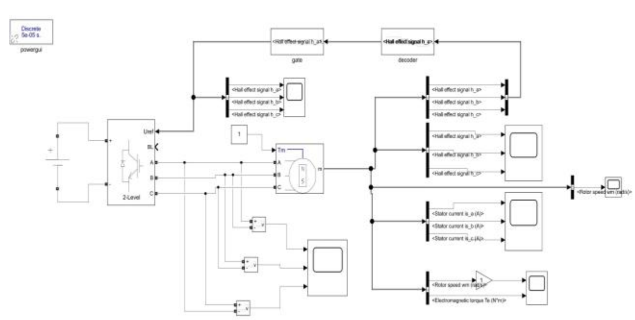

Fig. 1. Open loop BLDC motor system

5. Control Mechanism of Open Loop BLDC Motor System

By altering the analogous conceptual brush position and shifting the sensor location relative to the motor frame, it is possible to control the open-loop speed of BLDC motors in a manner similar to that of a connectional DC machine. Permanent magnet BLDC motors are widely used in industrial applications. When high torque is required for industrial application, they are crucial. The commutation parametrial is suitably selected in the open-loop. The motor will progressively pick up speed after selecting the right parameter, eventually operating in open-loop commutation mode at a constant speed. Electronic commutation of the BLDC motor is done in accordance with the motor position. Two of the three phases in each commutation sequence are related. PWMs can be used to control the average voltage delivered across the windings, which is utilized to control the speed, when the third phase of the power supply is left open.

6. Proposed Matlab model of open loop BLDC motor system

The MATLAB model for an open-loop control system for the BLDC motor is depicted in the figure 1. A dc power source is switched to the motor's stator phase winding by the power device, and the switching order is determined by the position of the motor. The BLDC motor's phase current has a rectangular shape. This is then timed to provide consistent torque at a constant speed in conjunction with the back emf. The mechanical commutation is increased by using the electronic switch. This, depending on the motor position, conveys the appropriate to the motor winding. A hall signal is used to determine the motor position, and depending on that signal, inverter switches are switched off to create a constant rotation. A three-phase supply is provided as input to a BLDC motor since it has a permanent magnet on the stator and a three-phase winding on the rotor. We are utilizing a 300V DC to AC two-level three-phase converter for that. The two-level three converters will transform the DC constant voltage into a sinusoidal three-phase waveform by having an AC side source resistance of 1e-3. The output is collected from the 3-level converter's (A, B, and C) points and delivered directly as input to the BLDC motor at (A, B, and C) points. The scope may be used to see how the voltage. Fig. 2 shows additional properties, such as hall effect signals (a, b, and c). The signal that was supplied to U_{ref} was vectorized to operate the converter. There are three reference voltages for this signal. Each phase will operate a converter to provide the desired voltage at this reference voltage in fig. 3. Fig. 4 shows stator currents (a, b, and c), and hall effect signals that are gathered from the bus that was obtained from are given to the gate, after which they are given to the 2-level converter at U_{ref}. In fig 5 show how the electromagnetic torque and rotor speed change over time. The specification of BLDC motor is shown in table 1.

Table 1
BLDC motor Parameters

Specification	Values
Number of phases	3
Torque	0.8 Nm
Speed	3000rpm
Vdc	300v
Stator phase resistance	18.7ohm
Armature inductance	0.02682 H
Flux Linkage	0.1716 Wb
Static friction	0
Back EMF waveform	Sinusoidal

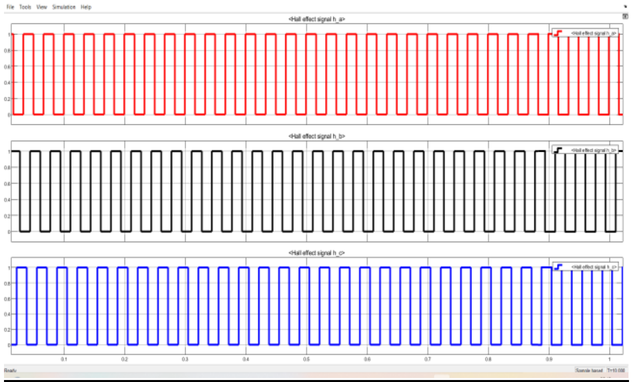

Fig. 2. Graph between hall effect signal (a, b, c) and time

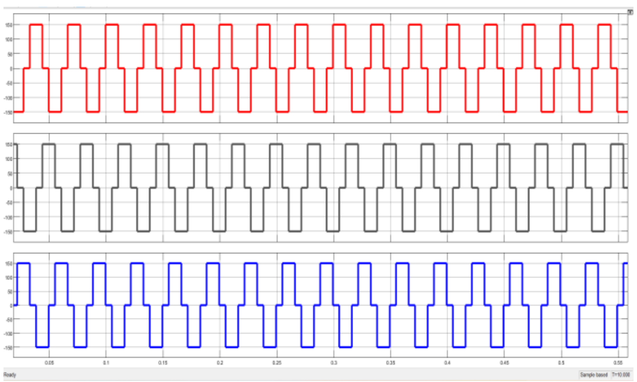

Fig. 3. Graph between voltage (a, b, c) and time

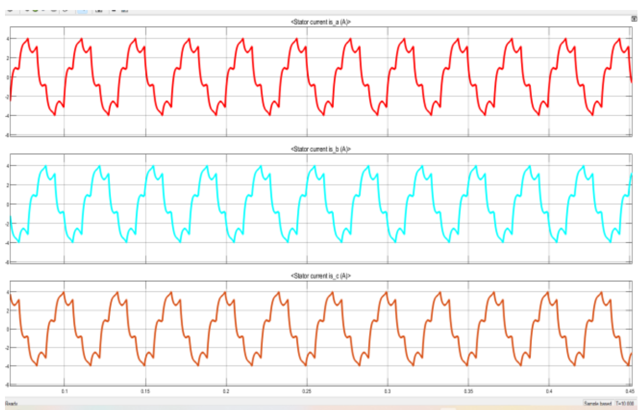

Fig. 4. Graph between stator current (a, b, c) and time

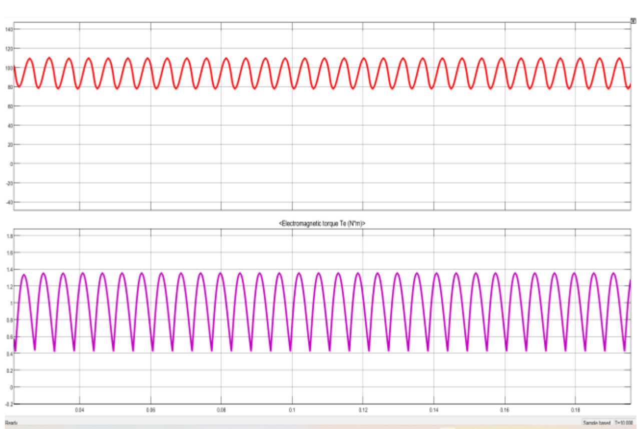

Fig. 5. Graph between rotor speed and electromagnetic torque vs. time

7. Proposed MATLAB Model of Closed Loop BLDC Motor System

Three different methods that a six-step inverter, speed regulation, and hall are employed to accomplish closed-loop control of a PM-BLDC motor. A three-phase MOSFET-based inverter supplies power to the motor. Where a hysteric's current controller introduces the PWM gating signal needed for fixing semiconductor components in the inverter. This is required to control steady current within the span of a motor's electrical revolution. The reference currents serve as a control for the actual current within the hysteresis band. Using a reference current generator, depending on the operation in steady state. The reference currents serve as a control for the actual current within the hysteresis band.

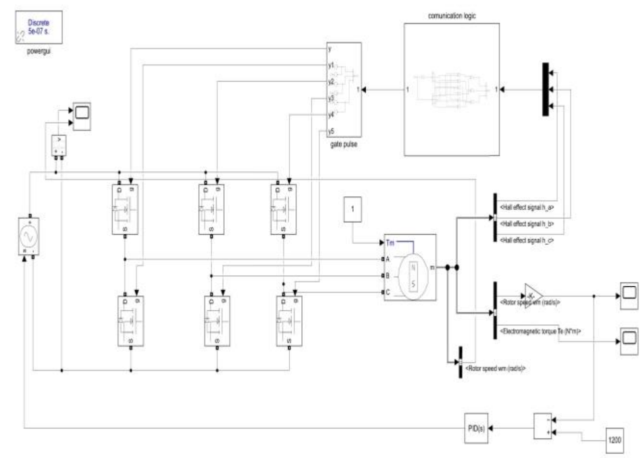

Fig. 6. Proposed closed loop model of BLDC motor system

In the MATLAB model indicated in fig. 6, inverters manufactured using six MOSFETs are provided a controlled DC supply. The MOSFET parameters are listed in Table 2.

Table 2
MOSFET parameters

Specification	Value
FET resistance	0.1 ohm
Internal diode inductance	0 H
Internal diode resistance	0.01 ohm
Internal diode forward voltage	350 V
Initial current (Ic)	0 A

These MOSFETs provide the pulsed DC steady supply to the BLDC motor after converting it to DC steady supply. And from there, M buses are removed to observe various parameters such as rotor speed, electromagnetic torque, and hall effect signal in the context of our observation for closed loop system feedback should be present to control and operate the machine at rated (or) constant speed, so the hall effect signal is given to communication logic. This communication logic will send the processed signal to gate pulse, which creates gate pulse for MOSFETs and triggers, controls the MOS, and then the gate pulse is sent to the MOSFETs in fig. 7 & fig. 8. Additionally, a rotor speed that was taken from another bus is added and used as a comparator to compare with 1200. PIDs receive the signal and transmit it to the regulated voltage source. Using a regulated voltage source, MOSFETs get varying voltage (inverter).

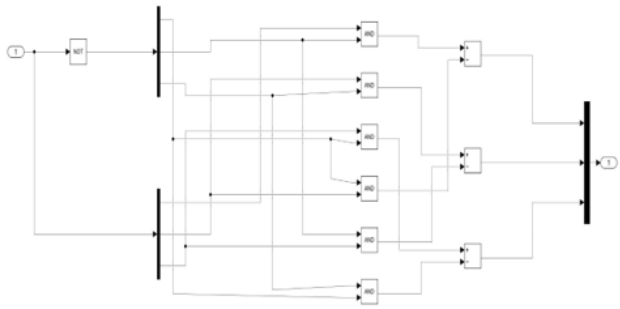

Fig. 7. Communication logic circuit

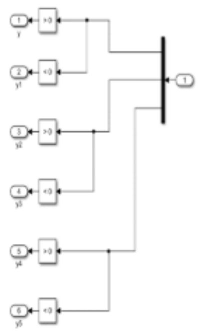

Fig. 8. Gate pulse generation

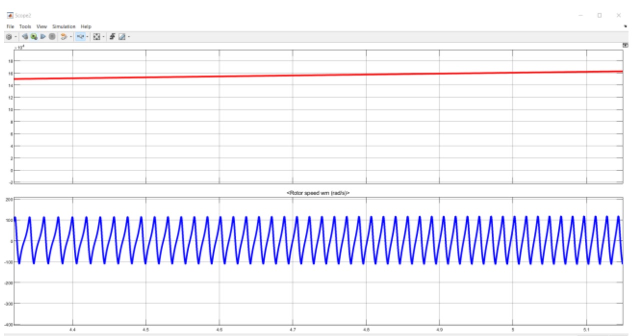

Fig. 9. Graph between rotor speed (rad/s) and time

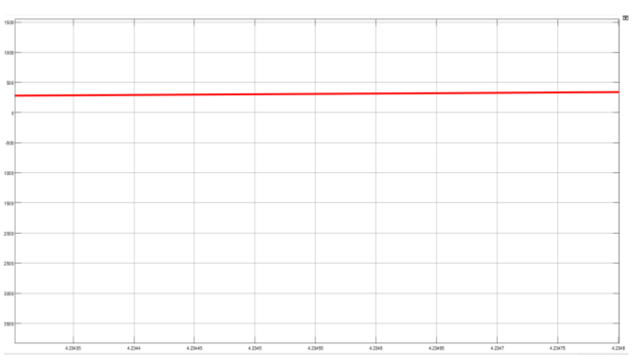

Fig. 10. Graph between electromagnetic torque and vs. time

The aforementioned graphs show some of the features of a closed-loop BLDC motor that were simulated using MATLAB, including electromagnetic torque, rotor speed, and speed vs. time. All of this explains how the BLDC motor was kept at a consistent speed. We really gave 1200 rpm as a reference in fig. 2 to show how the electromagnetic torque (nm) varied at startup to maintain the rotor speed, so it constantly tries to maintain the rotor speed at 12000 rpm. It is shown in fig. 9 & fig. 10.

8. Future Scope of the System

Under the suggested suitable circumstances, the desired outcome has been successfully attained. The proposed system design's control elements, however, might use some enhancement. In this experiment, the PI controller is effectively suggested for the motor speed control while the speed is maintained under the loaded condition. The manual tuning procedure was used to configure the final parameter value of the PI controller. In the future, in order to effectively manage the motor's speed, a PI controller adaptive technique may be utilized. The three-phase bridge inverter can use a variety of triggering methods, including SPWM and NSPWM.

9. Conclusion

This study illustrates the control of the BLDC motor in open-loop and closed-loop systems using MATLAB simulation. The motor model included a PI controller to regulate the motor's speed in response to the load. The technology selected is straightforward and economical because it only calls for a single current sensor to monitor dc-link current. It is evident from the closed-loop speed control result that the problem with speed and torque regulation that arose in the open-loop system has been resolved, i.e., the speed stays constant at the intended speed in closed-loop control approach.

References

[1] Alsayid, Basim, Wael A. Salah, and Yazeed Alawneh. "Modelling of sensored speed control of BLDC motor using MATLAB/SIMULINK." International Journal of Electrical and Computer Engineering 9.5 (2019): 3333.

[2] Suganthi, P., S. Nagapavithra, and S. Umamaheswari. "Modeling and simulation of closed-loop speed control for BLDC motor." 2017 Conference on Emerging Devices and Smart Systems. IEEE, 2017.

[3] Mohammed Ismail, Santanu Majumdar, Syed Suhail Albadri and Kruthi Jayaram." Simulation and Analysis of Closed Loop Speed Control of Brushless DC Motor." International Journal of Advanced Information Science and Technology, Vol. 3, No. 5, May 2014.

[4] Kamal, Md Mustafa, Lini Mathew, and S. Chatterji. "Speed control of brushless DC motor using intelligent controllers." 2014 Students Conference on Engineering and Systems. IEEE, 2014.

[5] Dubey, Menka, Shailendra K. Sharma, and Rakesh Saxena. "Design and development of quasi-resonant switched step-up converter for solar energy-based brush-less DC motor drive." International Transactions on Electrical Energy Systems 31.10 (2021): e12846.

[6] Vikhe, P. S., et al. "Speed Control of BLDC Motor using Open Loop PID Controller and Neural Network." International Journal of Engineering and Advanced Technology, 9.1 (2019).

[7] Gupta, Uma. "Research On Permanent Magnet BLDC for a small electric vehicle." 2014.

[8] Rajesh, R. G., and C. Balaji. "Speed control of BLDC motor using PID controller." International Journal of Advanced Research in Electrical, Electronics, and Instrumentation Engineering 3.4 (2014): 8826-8830.

[9] Kumar, Sathish & Sami, K. & Christy, Ananthi. (2018). Speed control of brushless Dc motor: Review Paper. Indian Journal of Public Health Research & Development. 9. 809.

[10] Ansari, Juhi Nishat, and L. Sapna. "Speed control of BLDC motor for electric vehicle." International Journal of Engineering Research & Technology (IJERT) 3.5 (2014): 1-6.