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A Review on Control and Analysis Methods of BLDC Motor

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ABSTRACT: Because of their reliability, high efficiency, high starting torque, and low electrical noise, brushless DC (BLDC) motors are widely utilized in a variety of industrial applications, including computer, aerospace, military, automotive, industrial, and domestic devices. Different controllers are used to control the speed of BLDC motors. This study presents a review of current developments in BLDC motor control and analysis methods.

KEYWORDS: Brushless DC (BLDC), Control and Analysis Methods, reliability, high efficiency, high starting torque, less electrical noise.

I. INTRODUCTION

Because of its high torque, compactness, and efficiency, the permanent magnet brushless dc (BLDC) motor is gaining prominence in computer, aerospace, military, automotive, industrial, and domestic sectors. The BLDC motor is fundamentally electronic controlled, and proper current commutation requires rotor position information. Brushless DC (BLDC) motors have been employed in a variety of applications, including computers, automatic office machines, robotics, electronic drives, and micro machines. The benefits of the BLDC motor are easy control, high torque, great efficiency, and compactness. Brush maintenance is no longer necessary, and shifting the position of the rotor and stator in a DC motor improves numerous problems caused by mechanical wear of brushes and commutators. An inverter and a position sensor that monitors rotor position for proper current commutation are required for the BLDC motor to alternate the function of brushes and commutator [3].

1. Construction of BLDC

Permanent magnets are attached to the rotor in this motor. On the stator are the current-carrying conductors, also known as armature windings. To turn electrical energy into mechanical energy, they employ electrical commutation. The replacement of the mechanical commutator with an electronic switch circuit is the primary design difference between brushed and brushless motors. A BLDC motor is a synchronous motor because the magnetic field created by the stator and the rotor both rotate at the same frequency. There are no current carrying commutators in a brushless motor. A brushless motor's field is switched by an amplifier, which is triggered by a commutating device such as an optical encoder. A BLDC motor is shown in Figure 1. The layout of a DC brushless motor can vary depending on whether it is in "Out runner" style or "Inrunner" style [11].

- **Outrunner** – A drum rotor rotates around the stator to form the field magnet. This design is suitable for applications that require a lot of torque but don't require a lot of rpm..
- **In runner** – The field magnet revolves inside the stator, which is a stationary drum. This motor is recognized for providing less torque than outrunner motors, yet it can spin at extremely high speeds.

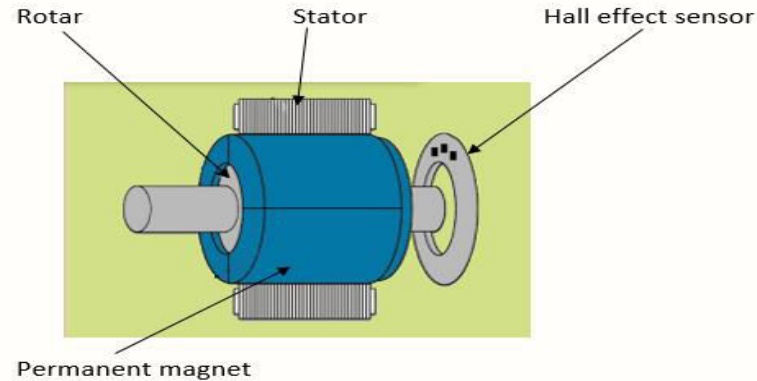


Figure 1 BLDC motor

II. EXISTING WORK

The performance of BLDC motors has been studied without and with standard controllers PI and PID by Lokesh Kumar Agrawal et al. [1]. The results were compared to those of a fuzzy-based controller. Fuzzy controllers provide good speed response when compared to conventional controllers, while conventional controllers provide greater reaction when the load changes. The investigation is carried out using MATLAB/SIMULINK software. Closed loop speed control of a BLDC motor drive using a PID controller loop is demonstrated in this research, and it is compared to a PI controller fed BLDC drive. The simulation results demonstrate that current ripple and torque ripple are reduced, which improves the drive's performance. The performance of a permanent magnet brushless dc motor with a PI and PID controller was compared, and it was found that when the load torque is applied to the motor with a traditional controller, the motor speed is reduced, and it should immediately restore its speed. When a load torque of 3 Nm is supplied to a motor with a PID controller for 0.1 second, the motor slows down and recovers speed much faster than with a PI controller. PID controllers have a faster rise time than PI controllers. The BLDC motor has no steady state error when using a PID controller, but there is considerable steady state error when using a PI controller. The PID response was compared to the fuzzy based BLDC motor response, and the simulation results demonstrate that when load torque is applied, the motor speed does not decrease. As a result, a fuzzy-based controller has a high efficiency. The results reveal that the motor's dynamic performance is fairly good under various loading circumstances.

Fuzzy based DTC for brushless dc drive machine has been proposed by M. Muthuvel and G. Udhayakumar et al. [2]. Essential DTC strategies for changing alternating current turns are classified as follows: the first is a hysteresis-based completely transferring desk DTC, followed by a few others that are regular switching consistency sample operating with a space vector modulation approach. Out of those strategies, we chose a DTC-based Fuzzy method because it has the ability to increase overall power performance while also reducing disorders in the and. According to the simulation results, the DTC-based Fuzzy System outperforms traditional controllers.

For the performance simulation of the BLDC motor, Rakesh Saxena et al. [3] uses a soft computing technique called PSIM. The relevant PSIM models for the BLDC can be simply generated using its user-friendly approach and some basic theories. In the PSIM environment, the simulation results of BLDC motor performance may be critically evaluated under various input settings. Comparing the simulation results in PSIM with the response acquired from the BLDC motor established findings can also be used to verify the accuracy of this approach.

The BLDC motor sensor less speed control system with fuzzy logic implementation is presented by J. Sriram and K. Sureshkumar [4]. It is proposed to use sensor less systems based on back EMF sensing and rotor position detection with a high beginning torque. Without the use of an extra sensor, the rotor position is aligned at standstill. Also, by changing the pulse width of the switching devices during alignment, the stator current may be easily altered, lowering the cost and complexity of the drive system without sacrificing performance. The suggested system's design analysis and simulation are carried out in MATLAB version 2010a, and the simulation results of sensory drive with PI controller and sensor less drive with proposed methodologies are studied.

Dr. Sridhar H.S et al. [5] use an Artificial Neural Network (ANN) and conventional controllers to develop a better speed control system for a Brushless DC motor. The planning, performance, and comparison of speed control of Brushless DC Motors utilising traditional controllers such as Proportional Integral Controllers (PI) and ANN enhanced Proportional Integral Controllers are discussed in this paper. To ensure that the suggested system is efficient, a simulation analysis is carried out. To verify the system's effectiveness, a comparative research is conducted. Circuit simulations were carried out using Matlab/Simulink. The nonlinear mapping capabilities of NNs is used here, as well as a tuning approach for the PI controller based on the Back-Propagation (BP) method. Only a PI controller and a NN tuned PI controller are used to regulate the speed of a brushless DC motor. MATLAB is used to run the simulation. Using a NN adjusted PI controller, rising time, peak time, peak overshoot, and settling time are lowered by 0.011 sec, 0.023 sec, 2.68 percent, and 0.06 sec, respectively, based on simulation findings and performance characteristics. As a result, employing a NN tuned PI controller improves overall system performance, and speed control of a BLDC motor using a NN tuned PI controller achieves higher performance characteristics than using merely a PI controller.

An attempt has been made by Adil Usman and Bharat Singh Rajpurohit [6] to examine the result of a PI Controller by applying the suitable K_p and K_i values in order to gain consistent control on the speed of a Brush Less Direct Current (BLDC) motor. In addition, an attempt has been done as an evaluation to develop an alternative controller to decrease steady state error and produce a better result for the management of the speed parameter of a BLDC Motor. To compare the PI Controller output with the FL Coutput, a Fuzzy Logic Controller (FLC) was created. After then, the data is compared and examined. As a result, the FLC has better adaptability than a traditional linear PI controller, and the PMBLDC drive has better steady state and dynamic performance.

S. Chaudhari et al. [7] discuss a DSP application for space vector modulation, which is then implemented in a three-phase voltage source inverter. When compared to other systems, this methodology makes the best use of the DC voltage delivered to the inverters. The aforementioned system was created for brushless DC motors (BLDC). The control technique is implemented using a dsPIC 30F3011. The firing signals are generated with MPLAB IDE software and C code. Various practical outcomes are documented. The voltage and current waveforms are nearly identical to a sinusoidal waveform. As a result, the current waveform has less distortion, and so there are less current ripples.

Bikram Das et al. [8] develop a brushless DC (BLDC) machine speed control technique, investigate the performance of the same motor under various speed and load torque settings, and lastly examine the BLDC motor's stability using various stability criteria. A soft computing technique is used in this case. PSIM was used to simulate the BLDC motor. The simulation findings of BLDC motor performance reveal that it provides good speed control results that can be critically examined in the PSIM environment using various input parameters. Comparing the simulation results in PSIM with the results of the response acquired from the BLDC motor can also be used to verify the accuracy of this approach.

According to C. MohanaPriya et al. [9], the current state of electrical engineering requires a multifaceted strategy. Because of their increased ability to use low inertia machines, higher torque in the low-speed range, high power density, cheap maintenance, and fewer rumour than conventional motors, brushless dc motors are more formalised in high-production applications. The BLDC motor mathematical model is enhanced in this paper. Finally, using Matlab/Simulink, the achievement of the BLDC motor is investigated, and the modelling results are instantaneous. Because the parameters of a BLDC motor are such an important aspect in the design of a BLDC motor drive system, it is vital to forecast the exact values of all the parameters, which are resolved by waveforms. For improved results, IOT methods could be used instead of MATLAB/SIMULINK in the future.

Speed control can be done with regular PI and PID controllers, according to V. Geetha and S. Thangavel [10]. The BLDC motor's direct torque control (DTC) is critical in many applications. PI, PID, and Fuzzy logic control are used to regulate a BLDC motor with DTC in this research. With the help of Matlab simulation software, the motor's performance is compared. By replacing the speed regulator with a PI, PID, or Fuzzy controller, the direct torque control of a BLDC motor with its dynamic performance is studied. Manually tuned PI and PID controllers produce results with a time delay. This time delay can be reduced by using a fuzzy logic controller. It also has the potential to improve the system's stability. The rules are applied to all three controllers, and the PI and PID controllers achieve steady state in 3.5 and 2.5 seconds, respectively. And the hazy outcomes are well attained with 2.3 seconds.

III. CONCLUSION

Brushless Electronically commutated motors are another name for DC electric motors. The primary efficiency of BLDC motors is a critical attribute. Because the rotor is the only magnet bearer and does not require any electricity. No connections, commutator, or brushes, for example. The motor uses control circuitry instead of these. BLDC motors use controllers, rotary encoders, or a Hall sensor to detect where the rotor is at specific times. This study presents a review of current developments in BLDC motor control and analysis methods.

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