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Analysis of Aurdino Based Control of BLDC Motor

Abstract: - Brushless DC (BLDC) motors are commonly used in various sectors, including Unmanned Aerial Vehicles (AUVs). However, to ensure reliable and seamless functioning, these motors require external control systems. One such system is the Electronic Speed Control (ESC), which can be used to control the motor using platforms like Arduino. This research aims to design a motor control system for the BLDC motor on the Arduino platform for use in a UAV with propellers. The use of Arduino is preferred due to its market availability, cost-effectiveness, and simplicity. This paper discusses the software implementation for motor control and explores the system's performance for wide range speed control and power quality improvement. The designed system's efficiency will enhance the performance of the UAV and ensure stable and precise motor control. The paper demonstrates the significance of the ESC in controlling the BLDC motor, and the use of Arduino as a platform for designing motor control systems. By the end of the research, a practical and efficient motor control system for BLDC motors on the Arduino platform is expected to be designed, which will find widespread applications in various sectors that use BLDC motors.

Keywords: Arduino, Brushless DC (BLDC) motor

I. INTRODUCTION

The Brushless DC (BLDC) motor is a type of electric motor that is widely used in various industries and applications, including Unmanned Aerial Vehicles (UAVs). However, to ensure flawless and reliable function, these motors require external control systems. One such system is the Electronic Speed Control (ESC), which is used to control the speed and direction of the motor. The Arduino platform, due to its simplicity, availability, and cost-effectiveness, has become a popular choice for controlling BLDC motors. The objective of this research is to design a motor control system for a BLDC motor on the Arduino platform, which can be used by UAVs with propellers. The system should be able to control the motor's speed and direction while also improving power quality [1]. To achieve this objective, software implementation is also included in the study. The Arduino platform is a microcontroller-based platform that provides an easy-to-use interface for controlling electrical components. It is widely available in the market and has a vast online community, making it easy to find support and resources for programming and design. Using the Arduino platform for motor control enables the use of various sensors, such as temperature, voltage, and current sensors, to monitor the motor's performance and ensure its safe operation [2]. The BLDC motor is an efficient and reliable motor, making it suitable for UAV applications. However, it requires a sophisticated control system to achieve maximum efficiency and performance [3]. The ESC provides this control by converting the DC power supply into three-phase AC power that drives the motor. The speed and direction of the motor can be controlled by varying the frequency and amplitude of the AC power [4]. The Arduino platform can provide the control signals required by the ESC to achieve precise control of the motor. The software implementation for the motor control involves developing an algorithm to control the motor's speed and direction [5]. The algorithm is based on the feedback from various sensors that monitor the motor's performance. The algorithm adjusts the frequency and amplitude of the AC power supplied to the motor to achieve the desired speed and direction [6].

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1.1. CONSTRUCTION AND WORKING OF BLDC MOTOR:

BLDC (Brushless DC) motors are constructed with three main components: stator,rotor, and electronic control unit. The stator is the stationary part of the motor and consists of a series of coils of copper wire wound around an iron core. The number of coils and their arrangement can vary dependingon the motor's intended use, but the most common configuration is a three-phase motor with the coils arranged in a star or delta pattern. The rotor is the rotating part of the motor and contains permanent magnets that produce amagnetic field. The number of magnets and their arrangement can vary depending on themotor's intended use, but most motors have either two-pole or four-pole rotors [7].

The electronic control unit (ECU) is responsible for managing the motor's operation by providing power to the stator coils in a specific sequence to create a rotating magnetic field. The ECU uses feedback from sensors to determine the motor's speed and position, allowing it to adjust the power supplied to the stator coils to maintain the desired speed. Overall, the construction of a BLDC motor is relatively simple, but its operation is highly complex, requiring precise control of the power supplied to the stator coils to maintain efficient operation [8].

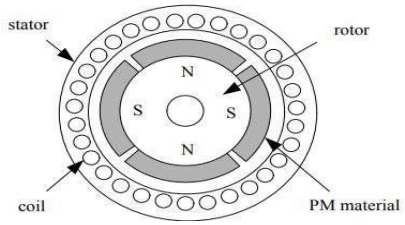


Figure 1.1: Construction diagram of BLDC motor

1.2. Working of BLDC motor:

When an external power source is applied to the stator windings, a magneticfield is generated, which interacts with the magnetic field produced by the permanent magnets on the rotor. The interaction between these two fields produces torque that causes the rotor to rotate. To ensure smooth rotation, the electronics continuously monitor the position of the rotor and adjust the energization of the stator windings to maintain the proper magnetic field orientation. The control of the energization of the stator windings is achieved using electronic commutation, which uses electronic switches (usually MOSFETs) to switch the power source between the different windings [9]. By switching the power source at the right time, the magnetic field can be rotated around the stator, causing the rotor to rotate as well [10].

In summary, a BLDC motor uses electronic commutation to control the rotation of a rotor with permanent magnets. The control of the energization of the stator windings is achieved using electronic switches, which are controlled by electronics that monitor the position of the rotor.

2.OBJECTIVE AND NECESSITY OF ARDUINO BASED BLDC MOTOR CONTROL

2.1. OBJECTIVE OF ARDUINO BASED BLDC MOTOR CONTROL

Brushless DC (BLDC) motors are widely used across various industries, from industrial machinery to consumer electronics, due to their superior efficiency, low maintenance, and extended lifespan compared to traditional brushed DC motors. A crucial aspect of operating a BLDC motor is controlling its speed, which involves adjusting the motor’s rotational speed. In this article, we will explore the purpose of BLDC motor speed control and its significance in different applications. The primary goal of controlling the speed of a BLDC motor is to regulate its rotation with precision and accuracy. This is achieved by managing the power supplied to the motor.

The speed of a BLDC motor is directly linked to the frequency of the current it receives. Therefore, by adjusting the current frequency, the motor’s speed can be precisely controlled. The importance of speed control in BLDC motors becomes clear when consider their applications. For instance, in industrial machinery, maintaining precise motor speed is critical for ensuring that equipment operates at the required performance level. In robotics, speed adjustments are necessary to control the robot’s movements with accuracy. Similarly, in consumer electronics like fans and air conditioners, controlling motor speed is essential to deliver the desired airflow and comfort.

2.2. NECESSISITY OF ARDUINO BASED BLDC MOTOR CONTROL

Brushless DC (BLDC) motors have low maintenance, and compact in size. However, BLDC motors requirea system of speed control to ensure optimal performance and prevent damage to the motor and its associated equipment. In this article, we will discuss the necessity of a system of speed control for BLDC motors. A system of speed control is necessary to maintain the speed of the BLDC motor at a desired level. This is particularly important in applications where precisespeed control is required, such as in robotics, medical devices, and CNC machines. Without a speed control system, the motor would run at a fixed speed, making it difficultto achieve the desired level of precision.

A speed control system is necessary to protect the motor from damage due to over-speeding or under-speeding. Over-speeding can cause the motor to overheat, leadingto a decrease in efficiency and lifespan, while under-speeding can cause the motor to stallor burn out. A speed control system can prevent these issues by regulating the speed of the motor within a safe range. A speed control system can provide additional features such as acceleration anddeceleration control, direction control, and torque control. These features can be useful ina wide range of applications, from conveyor systems to electric vehicles. Finally, a speed control system can help to reduce the noise and vibration produced by themotor. By controlling the speed of the motor, the system can ensure that it operates within a range that minimizes the level of noise and vibration. This is particularly important in applications where noise and vibration can be a significant issue, such as in medical equipment or audio equipment

3. BLOCK DIAGRAM AND WORKING OF ARDUINO BASED BLDC:

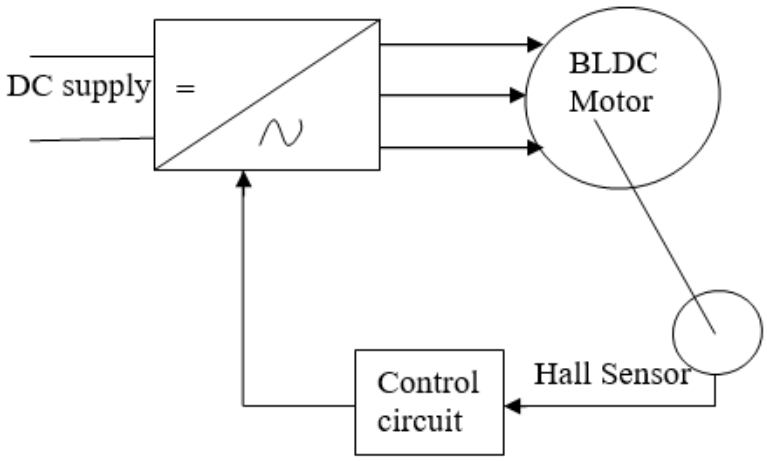


Figure 3.1: Block diagram of Arduino based control of BLDC motor

The Arduino IDE is open-source platform for Arduino or Node cu programming. This software is easily available with the web and it is simple and easy when as comparewith the other software. It also includes Library files of different external device to interface with the Arduino a boot loader has already been installed on Arduino Uno. Withthis boot loader, develop software without the necessity for an external programmerto program Arduino. The Arduino Uno is used to control the Electronic Speed Controller (ESC), which adjusts the motor speed based on the value from a potentiometer directly connected to the Arduino. The motor speed, expressed as a percentage, is displayed on a screen. The Arduino is programmed using C and C++. Figure 3.1 illustrates the basic block diagram for BLDC motor speed control, consisting of five key components: the potentiometer, the controller, the inverter, the BLDC motor, and an RPM measuring circuit.

To drive the BLDC motor, a three-phase six-switch inverter bridge is used. The controller generates a sequence to turn the inverter switches on and off. The output of the inverter is applied to the three stator windings of the motor. As the switching sequence changes, the current in the stator windings shifts, generating a magnetic field. This causes the rotor, made of a permanent magnet, to rotate in sync with the stator field. The rotor's position is detected by Hall sensors, which provide digital output to the controller, helping it generate the appropriate switching sequence for the inverter. Based on the programmed instructions, the controller generates six PWM signals that are sent to the inverter switches, converting DC power into the AC needed to run the motor. The RPM measuring circuit, which uses a controller, functions as a contactless tachometer. It interfaces with an LCD that displays the motor's RPM. Hall sensors detect the rotor's magnetic pulses, which are processed by the controller to determine RPM.

For controlling the speed of the BLDC motor, an electronic Brushless DC Controller, also called a Driver or Electronic Speed Controller (ESC), replaces the mechanical commutation system found in traditional Brush DC motors. These controllers use either Hall Effect Sensors or Back Electromotive Force (Back EMF) to determine the rotor's position, which is essential for operating the motor. Hall Effect Sensors, commonly used for speed detection, positioning, current sensing, and proximity switching, help detect rotor position through three embedded sensors. When combined with circuitry, these sensors can act as digital on/off switches. The inverter circuit utilizes a six-IGBT bridge, driven by PWM sequences generated by the controller. To regulate motor speed, a variable resistor functions as a variable frequency drive, allowing users to adjust the motor speed by modifying the duty cycle. Opto-couplers isolate the voltage on the controller side from the motor side, ensuring safety. The Hall sensors continue to monitor rotor position, allowing the controller to generate the next PWM signal and drive the inverter to keep the motor running efficiently.

3.1. ARDUINO CONTROLLED BRUSHLESS DC MOTOR

Testing an Arduino-controlled BLDC (brushless DC) motor can be a complex process, butcan be simplified into several steps. Here is a brief procedure for testing an Arduino- controlled BLDC motor:

Step 1: Gather Materials

The first step is to gather all the necessary materials. You will need an Arduino board, a BLDC motor, a motor driver board, a power supply, and appropriate wires and cables forconnections.

Step 2: Connect the Motor Driver Board

Connect the motor driver board to the Arduino board according to the manufacturer's instructions. Make sure to connect the motor driver board to the correct pins on the Arduino board.

Step 3: Connect the Motor

Connect the BLDC motor to the motor driver board. Again, make sure to connect the motor to the correct pins on the motor driver board.

Step 4: Connect the Power Supply

Connect the power supply to the motor driver board. Make sure the voltage of the power supply is appropriate for the motor and the motor driver board.

Step 5: Upload the Code

Upload the code for the Arduino-controlled BLDC motor to the Arduino board. This codewill be specific to the motor driver board and the motor being used. Make sure to follow the instructions provided by the manufacturer and double-check that the code is uploadedcorrectly.

Step 6: Test the Motor

Once the code is uploaded, you can test the motor. Start by running a simple program thatspins the motor at a low speed. Gradually increase the speed of the motor to test its performance. You can also test the motor by varying its direction and speed.

Step 7: Monitor the Motor

While testing the motor, monitor its performance using the Arduino serial monitor or a separate device like an oscilloscope. Make sure the motor is running smoothly and that itis not overheating or drawing too much current.

Step 8: Troubleshoot

If encounter has any problems during testing, troubleshoot the system to identify the issue.Check the connections, the code, and the settings to ensure everything is configured correctly.

3.2. ALGORITHM:

The given code is an Arduino program for controlling a brushless motor using a servo object and a potentiometer. The program reads the analog input from the potentiometer, scales it using the map () function, and sends the output to the ESC (Electronic Speed Controller) using the write () function. Here is a step-by-step algorithm for the code:

Include the Servo library for controlling the ESC.

Create a Servo object named ESC to control the ESC.

Define an integer variable named pot Value to store the value from the analog pin.In the setup () function:

a. Attach the ESC to digital pin 9 using the attach () function.

b. Set the minimum and maximum pulse width for the ESC using the attach () function.

In the loop () function:

a. Read the value from analog pin A0 using the analog Read () function and store it in potValue.

b. Scale the pot Value from the range 0-1023 to the range 0-180 using the map () function.

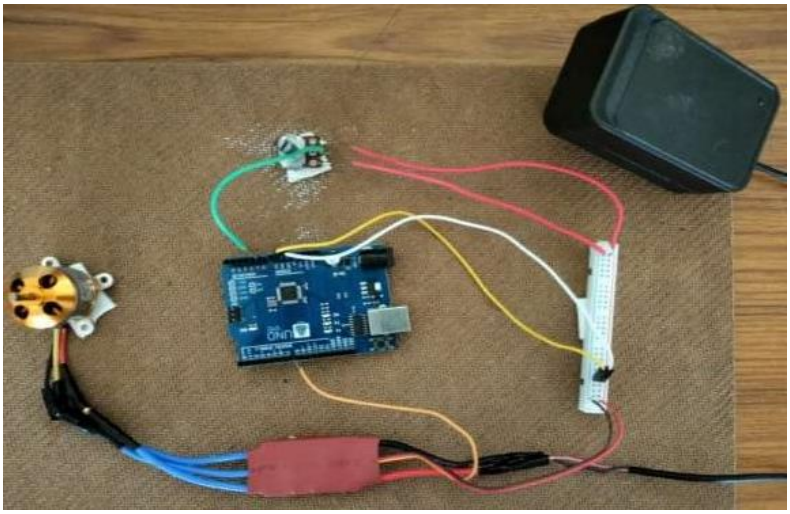
c. Send the scaled value to the ESC using the write () function.
Repeat steps in the loop () function to continuously update the motorspeed based on the potentiometer input.

4.HARDWARE IMPLEMENTATION AND RESULTS

An Arduino-controlled BLDC motor can offer a lot of benefits over traditional brushed motors, including higher efficiency, better torque control, and smoother operation. BLDC (Brushless DC) motors are electronically commutated motors, which means that the Arduino can control the motor's operation by sending precise electrical signals to the motor's coils. This allows for precise control of the motor's speed and torque, which can be very useful in applications where accuracy is important.

One of the primary advantages of using an Arduino-controlled BLDC motor is the abilityto easily implement closed-loop control. This means that the Arduino can sense the motor'sposition and adjust the power supply to the motor's coils in real-time to maintain a desiredspeed or torque. This can be useful in applications such as robotics or drones, where precise control is essential. Additionally, an Arduino-controlled BLDC motor can be used in a wide range of applications, including electric vehicles, home automation systems, and industrial machinery. The Arduino platform offers a lot of flexibility, allowing for easy customization and integration with other systems. Overall, an Arduino-controlled BLDC motor can provide a lot of benefits over traditional brushed motors, including improved efficiency, better torque control, and smoother operation. Whether you are a hobbyist or a professional engineer, an Arduino-controlledBLDC motor is a powerful tool that can help you achieve your goals.

Figure 4.1: Hardware Implementation of BLDC motor using Arduino



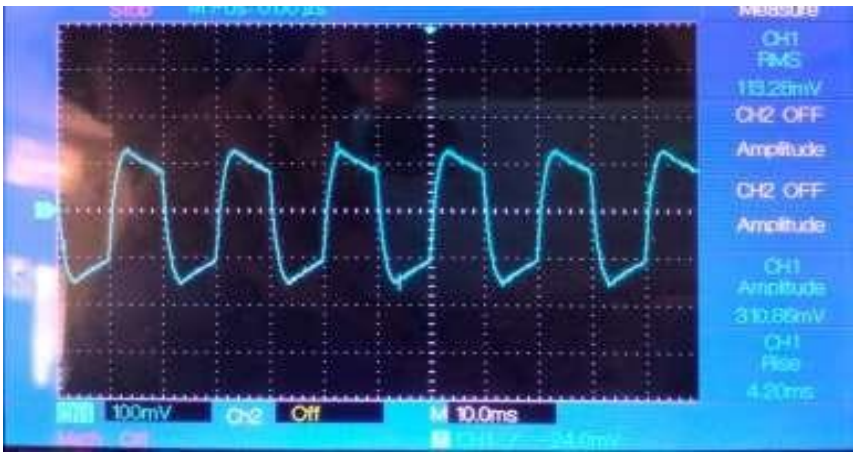


Figure 4.2: Voltage waveform at voltage level 100mV

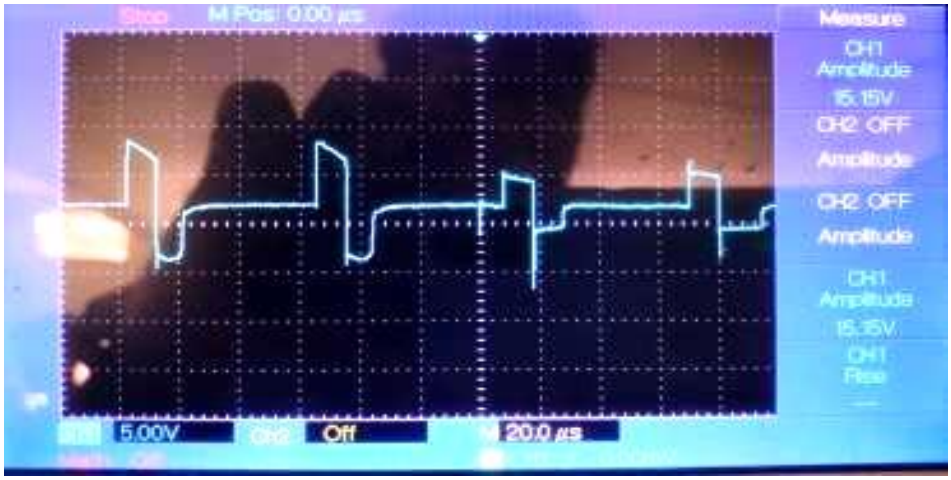


Figure 4.3: Voltage waveform at voltage level 5V

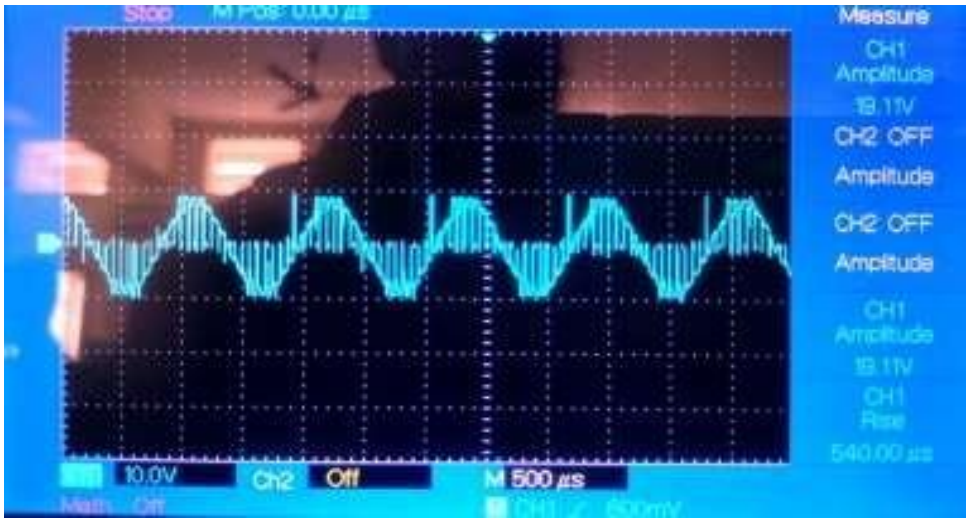


Figure 4.4: Voltage waveform at voltage level 10V

5. CONCLUSIONS

BLDC (Brushless DC) motors are widely used in various industrial, automotive, and aerospace applications due to their high efficiency, low maintenance, and compact size. An Arduino board used to control the speed and direction of a BLDC motor through a three-phase inverter. For control a BLDC motor, an Arduino board generated a sequence of signals thatenergize the motor's three windings in a specific order. By sensing the position of the rotor using sensors such as Hall-effect sensors or by estimating it using back-EMF (electromotive force) sensing, theArduino board switched the power supply to the motor's windings in the right sequenceto keep the rotor rotating smoothly.

The Arduino board can also adjust the motor's speed by adjusting the frequency of the signals applied to the motor's windings. Different voltage waveforms observed at different levels of voltages. This was achieved by varying the duty cycle of the PWM (pulse-width modulation) signals generated by the Arduino board. In conclusion, using an Arduino board to control a BLDC motor provides a cost-effectiveand versatile solution for various applications that require precise and efficient motor control. With the proper design and programming, an Arduino-based BLDC motorcontroller can be used in a wide range of industrial, automotive, and aerospace applications.

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