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DISCRETE BASED PWM SPEED REGUALTION OF BLDC MOTOR VIA ARDUINO UNO AND HC-05

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***Abstract*—Brushless DC (BLDC) motors are widely utilized in modern applications due to their high efficiency, superior torque density, and low maintenance requirements enabled by electronic commutation. This paper presents the design and implementation of an embedded system for BLDC motor speed control using pulse-width modulation (PWM) based on an Arduino Uno platform. The proposed system integrates an HC-05 Bluetooth module to facilitate wireless communication between an Android device and the controller. Control commands transmitted via the mobile application are received through a UART interface and processed by the microcontroller to generate appropriate PWM signals. An Electronic Speed Controller (ESC) regulates the motor operation by adjusting the applied voltage. The developed system demonstrates an efficient, flexible, and user-friendly approach for real-time BLDC motor control in various applications.**

***Index Terms*— BLDC motor, Arduino Uno, PWM control, HC-05 Bluetooth module, Electronic Speed Controller (ESC), wireless control, embedded system, speed control.**

I. INTRODUCTION

Brushless Direct Current (BLDC) motors have gained widespread attention due to their high efficiency, compact structure, and low maintenance requirements compared to conventional brushed motors. The elimination of mechanical brushes through electronic commutation enhances reliability, reduces wear, and improves overall performance. BLDC motors operate based on the interaction between the stator-generated magnetic field and permanent magnets on the rotor, with switching controlled by an Electronic Speed Controller (ESC). Rotor position is typically detected using Hall effect sensors, enabling precise commutation and smooth operation [1]. These features make BLDC motors suitable for applications such as electric vehicles, robotics, industrial automation, household appliances, and medical equipment.

In recent years, the integration of embedded systems and wireless communication technologies has significantly advanced motor control techniques. Conventional wired control systems are often associated with increased complexity, higher installation costs, and reduced flexibility. To address these limitations, wireless control methods, particularly Bluetooth-based systems, have emerged as

efficient and low-cost solutions [2]. In this context, the proposed system utilizes an Arduino Uno microcontroller and an HC-05 Bluetooth module to enable wireless speed control of a BLDC motor through an Android-based mobile application. The system employs Pulse Width Modulation (PWM) to regulate motor speed via the ESC, offering a flexible and user-friendly control mechanism.

Several research studies have contributed to the development of wireless and embedded motor control systems. Bhattacharjee *et al.* (2017) demonstrated BLDC motor control using an Android application and Bluetooth communication, highlighting the importance of secure pairing mechanisms for reliable operation [3]. Between 2018 and 2020, research trends emphasized cost-effective solutions based on Arduino platforms and PWM techniques for both DC and BLDC motors. During this period, N. Barsoum (2018) introduced GSM-based motor control using SMS and DTMF signals, establishing an early framework for remote motor operation using mobile devices [4].

Further advancements were made by Khanna *et al.* (2019), who developed an Android-based DC motor control system integrating Bluetooth and GSM technologies with PWM control [5]. Similarly, in 2020, researchers implemented wireless motor control systems using HC-05 Bluetooth modules, Arduino controllers, and motor driver circuits such as L293D, validating the effectiveness of short-range wireless communication for motor control applications [6].

As research progressed, greater emphasis was placed on BLDC motor systems due to their superior performance. Khedkar *et al.* (2020) developed a laboratory-scale BLDC motor controller using Arduino and ESC, demonstrating a strong relationship between PWM duty cycle and motor speed [7]. Additional enhancements included RPM measurement using IR sensors and real-time monitoring through LCD displays, as reported by the K.D.K.C.E. Nagpur group (2020) [8]. Bhattacharjee *et al.* (2020) further reinforced Bluetooth-based BLDC control, emphasizing secure and efficient wireless operation [9].

More recent studies have focused on advanced and intelligent control strategies. Abdul Rahman Abdul Majid (2024) proposed a Variation Model Filter (VMF)-based PID controller to improve speed control performance, achieving reduced overshoot and faster response compared to conventional methods [10]. In 2025, Misra *et al.* introduced an IoT-based BLDC motor control system using Arduino, ESP32, and the Blynk platform, enabling real-time monitoring and dual-mode control via both hardware and mobile interfaces [11].

Overall, the evolution of motor control techniques reflects a clear transition from traditional analog methods to modern digital approaches. PWM-based control using ESCs has become the standard due to its efficiency and simplicity, while advanced methods such as sensorless control and Field-Oriented Control (FOC) are employed in high-performance applications. However, for low-cost and educational systems, Arduino-based PWM control combined with Bluetooth communication remains a practical and effective solution. The proposed system builds upon these developments to provide a simple, secure, and efficient wireless BLDC motor control framework.

II. Types Of BLDC Motor's And Speed Control Methods.

Brushless DC motors can be grouped technically into different types based on electromagnetic geometry and position sensing.

Brushless DC (BLDC) motors are classified based on geometry, sensing technique, back EMF waveform, and pole configuration, each influencing performance characteristics and application suitability. Based on rotor–stator geometry, BLDC motors are categorized as in-runner, out-runner, and axial-flux types. In-runner motors are preferred for high-speed applications due to their low inertia and efficient cooling, whereas out-runner motors provide high torque at low speeds and are suitable for direct-drive systems. Axial-flux motors offer high power density and compact "pancake" structures, making them ideal for advanced applications such as electric vehicles.

From a control perspective, BLDC motors are divided into sensored and sensorless types. Sensored motors utilize Hall sensors for accurate rotor position detection, ensuring smooth operation at low speeds and high starting torque. In contrast, sensorless motors eliminate physical sensors and rely on back EMF, resulting in reduced cost and improved reliability, but with limitations in low-speed performance.

Based on back EMF characteristics, BLDC motors are classified as trapezoidal and sinusoidal types. Trapezoidal motors use simple six-step commutation but suffer from torque ripple and noise, while sinusoidal motors (PMSM) provide smoother operation with higher efficiency at the cost of increased control complexity. Additionally, motors are categorized by pole count, where single-pole motors achieve very high speeds, and multi-pole motors offer higher torque and smoother operation at lower speeds. The selection of a BLDC motor depends on application requirements such as speed, torque, efficiency, and control complexity, making these classifications essential for optimal system design.

The speed control of Brushless DC (BLDC) motors is achieved by regulating the voltage and current supplied to the stator windings through electronic commutation using inverter circuits and PWM signals generated by an electronic speed controller (ESC) or microcontroller. In open-loop control, speed is primarily regulated by adjusting the PWM duty cycle or varying the DC bus voltage, where an increase in duty cycle results in higher phase voltage and motor speed. However, open-loop methods lack accuracy under varying load conditions.

Closed-loop control enhances performance by incorporating feedback from sensors such as Hall sensors or encoders. A PI/PID controller processes the error between reference and actual speed and dynamically adjusts PWM signals to maintain desired performance. Voltage control governs motor speed, while current control regulates torque, as torque is directly proportional to stator current.

Conventional trapezoidal (six-step) commutation offers a simple and cost-effective solution but introduces torque ripple and noise. In contrast, advanced techniques such as Field-Oriented Control (FOC) or vector control enable independent control of torque and flux using Clarke–Park transformations, resulting in smoother operation, higher efficiency, and improved dynamic response.

Furthermore, sensorless control techniques eliminate the need for physical sensors by estimating rotor position using back EMF, flux linkage, or observer-based methods. Advanced control strategies such as Sliding Mode Control (SMC) and Model Predictive Control (MPC) further improve robustness, accuracy, and dynamic performance under varying operating conditions.

Overall, the selection of a suitable speed control technique depends on application requirements, balancing factors such as cost, complexity, efficiency, and control precision.

III. BLOCK DIAGRAM OF DISCRETE BASED PWM SPEED REGULATION OF BLDC MOTOR

A Brushless Direct Current motor is a type of synchronous motor that utilizes the power of direct current-derived power supplied to the motor through an electronic controller rather than the use of mechanical brushes.

In fig.1 depicts a wireless BLDC motor control scheme

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based on a Bluetooth technology platform with Arduino UNO at its core. The Android device uses a wireless medium represented by the HC-05 device to communicate with the Arduino UNO. It transmits control signals wirelessly to the Arduino UNO. The Arduino UNO processes control signals and provides control signals to the ESC, which manages the supply of power from the LiPo battery to the BLDC motor. A 16x2 LCD is connected to the Arduino UNO.

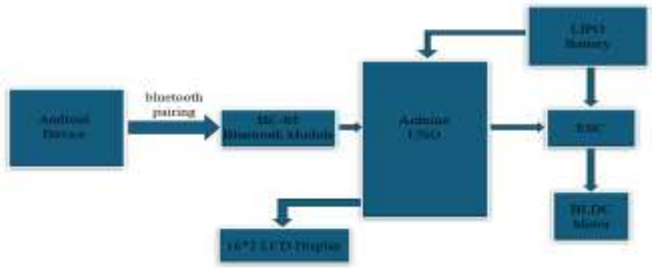

Fig.1. Block Diagram of the Prototype a wireless BLDC motor control

A. HC-05 Bluetooth Module (Fig.2):

HC-05 Bluetooth module receives control commands transmitted from an Android device via Bluetooth communication and forwards them to the Arduino Uno in serial format for further processing.

Fig. 2. HC-05 Bluetooth Module

B. Arduino Uno (Fig. 3):

The Arduino Uno acts as the central controller, receiving commands from the HC-05 Bluetooth module and processing them accordingly. It generates PWM signals to control the ESC for motor speed regulation and simultaneously transmits real-time operational data to the LCD display.

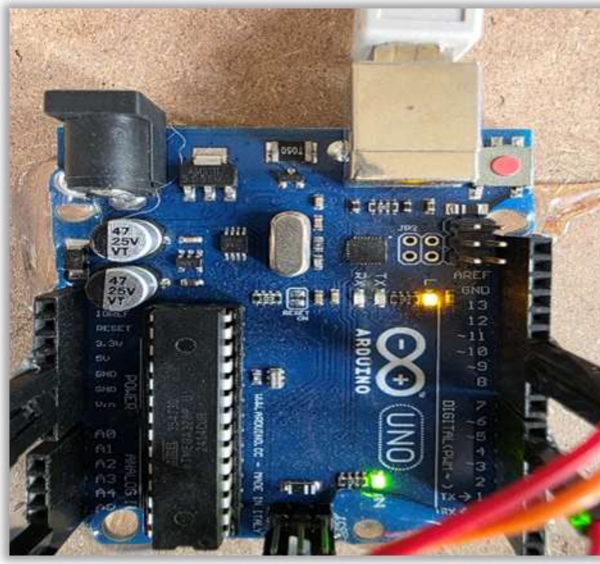

Fig. 3. Arduino UNO Micro-Controller

C. Electronic Speed Controller (Fig.4):

The Electronic Speed Controller (ESC) receives PWM signals from the Arduino and converts the DC power supplied by the LiPo battery into a controlled three-phase output for driving the BLDC motor. It regulates the motor's speed and direction in accordance with the commands issued by the Arduino.

Fig. 4. Electronic Speed Controller

D. BLDC Motor (Fig. 5):

The BLDC motor acts as the primary mechanical output device, converting electrical energy supplied by the ESC into rotational motion. Its speed is controlled through PWM signals generated by the Arduino based on the commands received.

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Fig. 5. BLDC Motor

E. LiPo Battery (Fig. 6):

The Lithium Polymer (LiPo) battery serves as the primary high-current power source of the system. It supplies the required DC power directly to the ESC for driving the BLDC motor.

Fig. 6. Li-Po Battery (11.1V)

F. 16×2 LCD Display (Fig. 7):

The 16×2 LCD display is interfaced with the Arduino Uno to present real-time system parameters and operational data.

Fig. 7. 16*2 LCD Display

IV. Simulation Circuit

The proposed system is an Arduino-based BLDC motor control setup with Bluetooth connectivity, as illustrated in Fig. 8. The hardware components include an Arduino Uno, HC-05 Bluetooth module, 30A Electronic Speed Controller (ESC), BLDC motor, 16×2 LCD display, and a 2200 mAh LiPo battery as the primary power source.

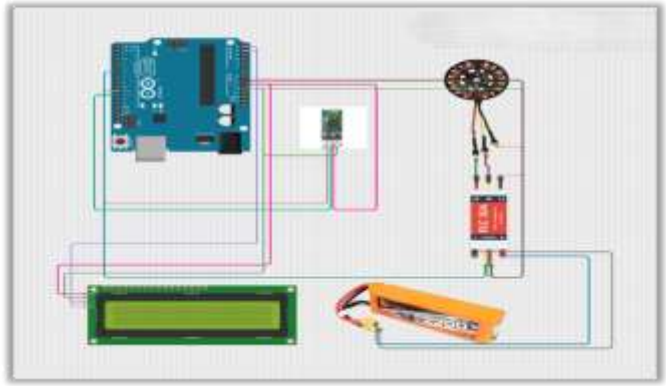

Fig. 8. Simulation Circuit of the Prototype

The LiPo battery provides high-current DC power directly to the ESC, which in turn converts it into a controlled three-phase supply for driving the BLDC motor. The Arduino Uno is powered through the regulated 5V output provided by the ESC, ensuring stable operation of the control circuitry.

For motor control, the Arduino generates PWM signals that are transmitted to the ESC via a signal line. Based on these PWM inputs, the ESC regulates the motor speed by adjusting the effective voltage and commutation of the three-phase output.

The HC-05 Bluetooth module is interfaced with the Arduino using UART communication (TX and RX pins). It enables wireless transmission of control commands from an Android device, allowing real-time speed and direction control of the motor.

The 16×2 LCD display is connected to the Arduino via the I2C protocol using SDA and SCL lines. It is utilized to display real-time system parameters such as motor speed and operating status.

V. Hardware setup

The experimental hardware setup of the proposed BLDC motor control system is illustrated in Fig. 9. The system integrates an Arduino Uno, HC-05 Bluetooth module, Electronic Speed Controller (ESC), BLDC motor, 16×2 LCD display, and a LiPo battery.

1) HC-05 → Arduino Uno:

The HC-05 Bluetooth module is interfaced with the Arduino using UART communication. The module is powered using a 5V supply and common ground, while TX and RX pins enable serial communication. Since the HC-05 RX pin operates at 3.3V logic, a voltage divider is employed between the Arduino TX and HC-05 RX line to ensure safe operation.

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2) 16×2 LCD → Arduino Uno:

The LCD display is connected to the Arduino via the I2C protocol using SDA and SCL lines, along with power and ground connections. This configuration reduces wiring complexity and enables real-time data display.

3) LiPo Battery → ESC:

An 11.1V LiPo battery is used as the primary power source. It is connected to the ESC through an XT60 connector, supplying high-current DC power required for motor operation.

4) ESC → Arduino Uno (PWM and Power):

The ESC is connected to the Arduino using a 3-wire servo connector. The PWM signal from the Arduino controls motor speed, while the built-in Battery Elimination Circuit (BEC) of the ESC provides a regulated 5V supply to power the Arduino, eliminating the need for an external power source.

5) ESC → BLDC Motor:

The ESC supplies three-phase AC power to the BLDC motor through three output wires. The direction of rotation can be reversed by interchanging any two of these phase wires.

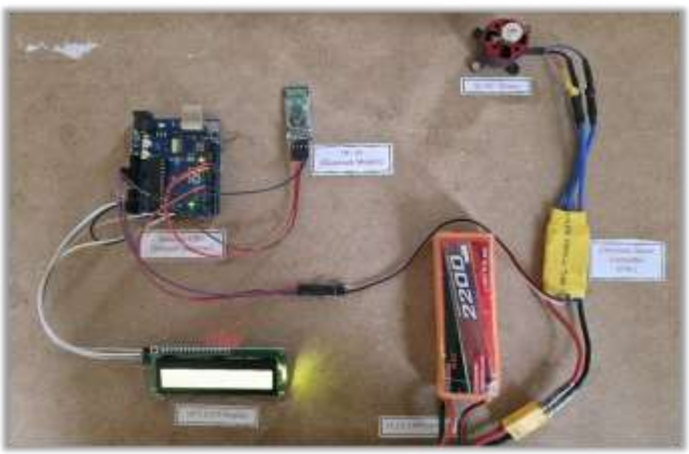

Fig.9. Hardware Setup

Components used for the hardware and their ratings are tabulated in Table I.

TABLE I
HARDWARE COMPONENTS RATINGS

Component Name	Operating Ratings
BLDC Motor	7.4V – 11.1V
HC-05	3.6V – 6V, 30–40mA
Arduino UNO	5V, 490–980 Hz, 16 MHz
16*2 LCD Display	5V, 20–30mA (backlight on)
ESC	7.4V – 11.1V (2S–3S LiPo), 5V, 2A
Li-Po Battery	11.1V, 2200mAh

VI. RESULTS AND DISCUSSION

The proposed Bluetooth-controlled BLDC motor system was successfully implemented using an Arduino Uno, HC-05 Bluetooth module, Electronic Speed Controller (ESC), 16×2 LCD display, and a BLDC motor. The system enables real-time wireless control of motor speed using a smartphone interface.

As shown in Fig. 10, the smartphone is paired with the HC-05 Bluetooth module, enabling wireless communication. The user transmits speed commands in the form of single-character ASCII values (‘0’ to ‘9’), which are received by the HC-05 module and forwarded to the Arduino via UART communication (typically at 9600 baud rate). The Arduino processes the received data and converts it into corresponding PWM signals for motor control.

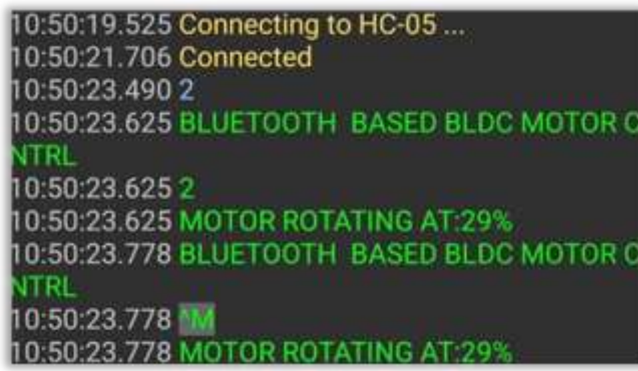

Fig.10. HC-05 Interfacing with BLDC Motor

The Arduino generates PWM output signals (using analogWrite or ESC-compatible pulse signals), which are applied to the ESC. The ESC then converts the DC power from the 11.1V LiPo battery into a controlled three-phase supply to drive the BLDC motor. The PWM duty cycle determines the effective voltage supplied to the motor, thereby controlling its speed.

Fig. 11 and 12 illustrate the real-time output displayed on the 16×2 LCD. The first line displays the status message “MOTOR ROTATING @”, while the second line indicates the motor speed in percentage (e.g., 19%, 29%). This provides a simple and effective user interface for monitoring system performance.

Fig. 11. Motor rotating at 19%

Fig. 12. Motor rotating at 29%

The relationship between duty cycle, average voltage, and motor speed is presented in Table II. The PWM duty cycle is mapped to discrete speed levels using a predefined lookup table ranging from 0% to 99%. The average voltage is calculated using the relation:

$$V_{avg} = D \times V_{supply}$$

where D is the duty cycle and V_{supply} is 5V. The results indicate that as the duty cycle increases, both the average voltage and motor speed increase proportionally.

TABLE II
COMPARISON OF VARIOUS PARAMETERS

Step	Duty-Cycle (%)	Average Voltage (V)	Speed (rpm)
0	0	0	0
1	19	0.95	262.2
2	29	1.45	400.2
3	39	1.95	538.2
4	49	2.45	676.2
5	59	2.95	814.2
6	69	3.45	952.2
7	79	3.95	1090.2
8	89	4.45	1228.2
9	99	4.95	1366.2

The experimental data shows that the motor speed varies from 0 rpm at 0% duty cycle to approximately 1366 rpm at 99% duty cycle. This demonstrates a near-linear relationship between PWM duty cycle and motor speed, as illustrated in Fig. 13. The linearity confirms effective control of motor speed using PWM techniques.

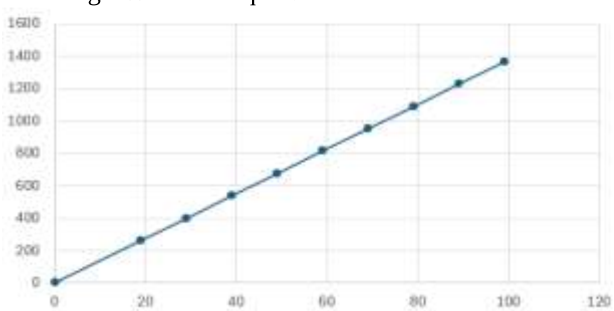

Fig. 13. Graphical Representation of Duty-Cycle vs Speed

Similarly, Fig. 14 illustrates the relationship between duty cycle and average voltage. The graph shows a direct proportionality, where the voltage increases linearly from 0 V to 5 V as the duty cycle varies from 0% to 100%. This validates the theoretical expectation of PWM-based voltage control.

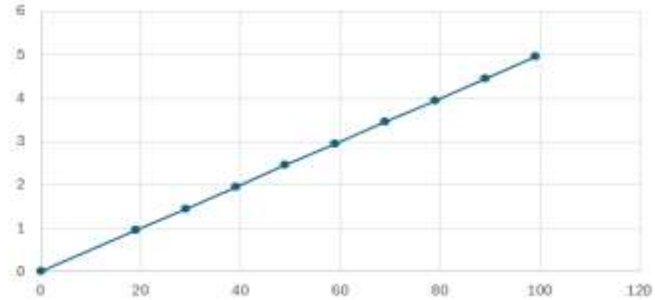

Fig. 14. Graphical Representation of Duty-Cycle vs Average Voltage

Overall, the system demonstrates reliable wireless operation, smooth speed variation, and effective integration of hardware components. The results confirm that the proposed method provides a simple, cost-effective, and efficient solution for BLDC motor speed control, suitable for applications such as robotics, automation, and remote-controlled systems.

VII. CONCLUSION

The proposed system successfully demonstrates a Bluetooth-controlled BLDC motor drive using an Arduino Uno as the central controller. The hardware implementation integrates key components, including an Android device, HC-05 Bluetooth module, Arduino board, 16×2 LCD display, Electronic Speed Controller (ESC), and a BLDC motor, all powered by a single 11.1V LiPo battery.

The Android device wirelessly transmits speed control commands to the HC-05 module, which forwards the data to the Arduino via serial communication. The Arduino processes these inputs and generates appropriate PWM signals to control the ESC, thereby regulating the motor speed. Simultaneously, the system provides real-time feedback through the LCD display, indicating motor status and operating conditions. The ESC efficiently converts DC power into a three-phase supply for the motor and utilizes its built-in Battery Elimination Circuit (BEC) to provide a regulated 5V supply for the control circuitry.

The experimental results confirm that the system achieves reliable wireless communication, smooth speed variation, and effective motor control. The use of a 2200 mAh LiPo battery ensures sufficient power delivery and stable operation. Overall, the proposed system offers a simple, cost-effective, and efficient solution for remote BLDC motor control.

This work provides a strong foundation for further development in advanced applications such as drones, electric vehicles, robotics, and industrial automation systems, where precise and wireless motor control is essential.

References

[1] T. Kenjo and S. Nagamori, *Permanent Magnet and Brushless DC Motors*. Oxford, U.K.: Clarendon Press, 1985.

[2] M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, *The 8051 Microcontroller and Embedded Systems*. Pearson, 2006.

[3] S. Bhattacharjee *et al.*, "Bluetooth-based BLDC motor speed control using Android application," *International Journal of Engineering Research*, 2017.

[4] N. Barsoum, "Speed control of DC motor using mobile phone," *International Journal of Scientific Research*, 2018.

[5] A. Khanna *et al.*, "Android-based DC motor speed control using Bluetooth and GSM," *International Journal of Engineering and Advanced Technology*, 2019.

[6] R. Kumar *et al.*, "Wireless DC motor control using Arduino and HC-05 module," *International Journal of Engineering Research & Technology (IJERT)*, 2020.

[7] P. Khedkar *et al.*, "Arduino-based BLDC motor speed control using PWM," *IRJET*, vol. 7, no. 6, 2020.

[8] K.D.K.C.E. Nagpur Group, "BLDC motor speed control with RPM measurement using IR sensor," 2020.

[9] S. Bhattacharjee *et al.*, "Wireless BLDC motor control using Android application," *IJCRT*, 2020.

[10] A. R. A. Majid, "Enhanced BLDC motor control using VMF-based PID controller," 2024.

[11] R. Misra *et al.*, "IoT-based BLDC motor monitoring and control using ESP32 and Blynk," 2025.