

Energy Efficient BLDC Fan

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Abstract - An electronic commutation system, as opposed to a mechanical commutator and brushes, powers a brushless DC (BLDC) motor, which is a synchronous electric motor that runs on direct current (DC) electricity. In BLDC motors, current to torque and voltage to rpm have linear relationship. This linearity provides an excellent opportunity to use the BLDC motor in conventional ceiling fans. This project seeks to practically implement a BLDC motor as a ceiling fan and introduce several BLDC fan speed control methods. This fan is implemented with three different modes of operations-manual mode, auto mode, remote control mode. In manual mode, speed is controlled by potentiometer. In Auto mode, the speed of fan is automatically changed as per room temperature, for this LM35 sensor is used. In Remote control, mode the speed can be adjusted by remote controller device. IR sensor is used for remote control operation.

Keywords-Brushless DC (BLDC) motors, ceiling fans, energy efficiency, electronic switch controller

I.INTRODUCTION

In the fast-growing era of 21st century where power consumption is at its peak due to heavy industrial revolutionization and urbanization in India, lot of power is consumed as compared to its generation. To counter this, fans with BLDC were introduced, so as to generate a greater output with very less input power. According to recent studies residential sector has become the topmost power consuming sector due to various factors like day-day home appliances. After a thorough study on residential power uses, it has been discovered that alone ceiling fan consumes 7% of total power supply which is more than combined power consumed by TV and fridge. The main purpose of our project to reduce power consumption of fan by 50% without interrupting the performance and features.

A brushless DC (BLDC) motor is a synchronous electric motor that operates on direct current (DC) electricity and features an electronic commutation mechanism in place of a mechanical commutator and brushes. Current to torque and voltage to rpm in BLDC motors are linearly related. This linearity offers a great chance to employ BLDC motors in traditional ceiling fans. This study offers the actual power measurements in contrast to ordinary ceiling fans, as well as the practical installation of such BLDC motor for ceiling fan application.

II.LITERATURE SURVEY

In [1], V. Champa et al. highlights the drawbacks of induction motor (IM) ceiling fans, such as consumption of power and limited control. BLDC motors are introduced as a solution, offering energy efficiency, reliability, and precise speed control. Adopting BLDC ceiling fans in homes can save a significant amount of energy; high voltage BLDC fans with active boost power factor correction (PFC) for increased efficiency are the subject of this discussion. the BLDC motor control schemes, distinguishing between sensor-based and sensor-less methods Techniques for align and go, sluggish first cycle, and initial position detection are among the many sensor-less control approaches covered in detail. The features of sensor-based and sensor-less BLDC motor control are compared in a table.

In [2], Tahir Izhar et al. The global energy crisis and the need for energy efficiency and conservation at both micro and macro levels are described. It emphasizes the importance of integrating energy-efficient technologies into basic domestic electrical appliances, with a specific focus on ceiling fans. Conventional ceiling fans with single-phase induction motors consume a significant amount of electricity, approximately 80 watts. These fans contribute significantly to residential electricity consumption, especially in warmer regions.

In [3], Sushrut Manu Singh et al. The performance of a regulated rectifier with several DC-DC converter-based systems in order to determine how effective it is in driving a Brush less DC (BLDC) motor for ceiling fans. The suggested model includes proportional-resonant (PR) control for the rectifier and closed-loop control for the BLDC motor, which includes speed and hysteresis current regulation. To validate the suggested model, the study comprises simulations run on the MATLAB/SIMULINK platform. The outcomes show increased speed and torque control throughout a range, as well as an improved power factor. Brushless DC motors are becoming more and more popular for use in electric vehicles, HVAC

systems, and ceiling fans because of their good torque-to-weight ratio, excellent speed control, and great efficiency. The study emphasizes the requirement for energy-efficient ceiling fan motor solutions

In [4], Stefan Leitner et al, introduces a novel design for an outer-rotor BLDC claw-pole motor, specifically designed for sub-fractional horsepower fan applications. Traditional skewing techniques used to reduce cogging torque in such motors often result in undesirable axial magnetic forces, leading to noise and reduced bearing system lifetimes. The proposed design employs V-shaped claw-poles, enabling cogging torque reduction through skewing while balancing axial magnetic forces. Unlike other techniques, these design improvements can be incorporated without increasing manufacturing costs. This is particularly important for cost-sensitive applications such as automotive auxiliary drives.

In [5], Guo qin Wang et al. The design of a Brushless Direct Current (BLDC) controller for an automobile engine cooling fan system with independent intellectual property is also used. The controller is designed to control a four-phase sensor less BLDC motor with bifilar windings. It utilizes a half-wave circuit, which provides high torque performance comparable to a full-bridge circuit, but with lower cost, higher efficiency, and greater reliability. The controller employs a multi-task operation algorithm designed for automotive electronic control systems. This algorithm separates tasks such as out-of-step protection, over-current protection, over/under-voltage protection, open/short circuit protection, and communication diagnostics based on their priority and utilizes time-based multi-task operation to ensure high reliability and real-time performance.

III. WORKING

The capacity to control speed over a wide range is a BLDC motor's most notable characteristic. There are various ways to regulate the speed.

Mode Choice

There are three different control modes that can adjust the fan speed: manual, auto, and remote control, which is operated by a switch. Every mode has benefits of its own. The pulse width from the micro controller ATmega16 to the ESC (Electronic Switch Controller) is adjusted to control speed, independent of the operating mode. The output from the microcontroller determines the speed of the BLDC motor, which is controlled by the ESC.

1) In manual mode when operating manually, the potentiometer is used to modify the pulse width from the micro controller, which in turn controls the speed. Through the potentiometer, the reference voltage can be adjusted to control the pulse width.

One can regulate the motor's speed by adjusting the pulse width.

2) Set in Auto

The LM35 temperature sensor is utilized in auto mode. It measures the temperature of the room and adjusts the LM35's output voltage accordingly, which modifies the micro controller's input. When working manually, the micro controller's pulse width is adjusted using the potentiometer, which then regulates the speed. The pulse width can be controlled by varying the reference voltage via the Potentiometer. The pulse width can be adjusted to control the motor's speed. regulated by varying the pulse from the microcontroller; in this case, a change in ambient temperature will alter the LM35's output voltage, which will alter the microcontroller's pulse width. The microcontroller is configured to detect these modifications.

3) Mode of Remote Control

When in remote control mode, an IR Sensor is utilized for wireless control and a remote controller regulates the operating speed. There are two switches on the remote

controller for controlling speed: up and down switches used for regulating the operating speed.

Controlling Speed of motor:

Speed (RPM)=Power(kv) \times Voltage(V)

If we want the motor to spin at 1400 RPM, we need to apply a voltage of 1 volt ($1400 \text{ KV} \times 1 \text{ V} = 1400 \text{ RPM}$ $1400 \text{ KV} \times 1 \text{ V} = 1400 \text{ RPM}$).

If we want the motor to spin at 7000 RPM, we need to apply a voltage of 5 volts ($1400 \text{ KV} \times 5 \text{ V} = 7000 \text{ RPM}$ $1400 \text{ KV} \times 5 \text{ V} = 7000 \text{ RPM}$).

IV. BLOCK DIAGRAM

The aim of this project is to develop an energy-efficient fan using BLDC motor, with different modes of speed control. This model comprises of motoring part, micro controller part and controlling part. Figure 4.1 shows the block diagram of the implemented system.

Motoring part includes BLDC motor (1400KV). The speed of the motor is controlled by an ESC (Electronic Speed Controller). The speed of the motor varies according to the variation in the pulse width of the microcontroller.

Atmega16 micro controller is programmed for generating pulses which is further varied with the input control signal.

The controlling part has three sections such as potentiometer, an LM35 temperature control and a RF module, among which any of the modes can be selected according to the requirement of user.

The model is implemented with three modes of working- manual mode, automatic mode and remote control mode. In manual mode, speed can be controlled by adjusting a potentiometer. In auto mode, speed is automatically controlled according to the room temperature with the help of a temperature sensor where the sensor senses the room temperature and compares it with the reference temperature. Speed is varied according to the difference between the two temperatures-reference and room temperatures. In remote control mode operation, speed can be adjusted by using a remote controller control with IR sensor.

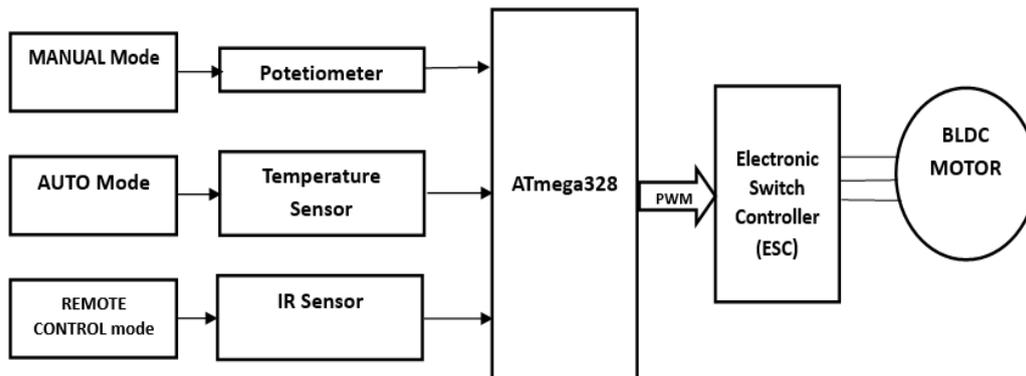


Fig 4.1: Block Diagram

V. METHODOLOGY

1. Understanding BLDC Technology Brush Less DC Motors (BLDC): Unlike conventional brushed DC motors, BLDC motors use electronic commutation instead of mechanical brushes. This results in higher efficiency, less maintenance, and longer life.

2. Key Components of a BLDC Fan

Motor: The heart of the BLDC fan, where efficiency gains are most significant.

Electronic Controller: Manages the commutation electronically and optimizes power usage.

Fan Blades: Aerodynamic design to reduce air resistance and noise. Ensures optimal airflow and minimal vibration.

3. Design Considerations

Electronic Controller:

Commutation Control: Implement efficient algorithms like Field-Oriented Control (FOC) for precise motor control.

PWM Techniques: Use Pulse Width Modulation (PWM) to efficiently regulate motor speed.

Sensor less Control: If feasible, implement sensor less control to reduce complexity and cost.

Aerodynamic Design:

Blade Shape: Optimize the blade shape for minimal drag and maximal airflow.

Material: Use lightweight, durable materials like composites to enhance efficiency.

Angle of Attack: Adjust the blade pitch for optimal performance at various speeds.

4. Prototyping and Testing

Prototyping: Build prototypes based on the optimized designs.

Performance Testing: Measure efficiency, airflow, noise levels, and durability.

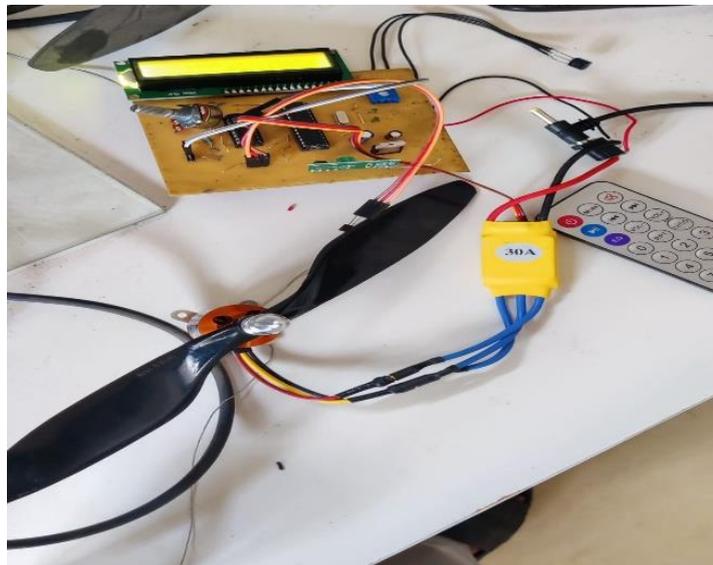


Fig 5.1: Energy Efficient BLDC Fan

This project includes a fan with three different modes. manual mode, automated mode and remote control mode that can be used to change the speed of the BLDC motor. This energy efficient fan allows for variable speed control, depending on the user's preference using various approaches. The speed can change by adjusting the duty cycle of the waveform. The duty cycle can be adjusted using three different methods manually. Brushless DC motors are frequently more effective in turning electrical energy into mechanical energy. Brushed DC motors are less efficient at converting electrical energy into mechanical energy compared to brushless DC motors. AC motors experience significant electrical and frictional losses.

VI. CONCLUSION

A ceiling fan solution based on BLDC motors will shed light on the current situation, the difficulties encountered in coming up with a solution, and some of the fundamental principles governing DC, BLDC, and AC motors in general. This project analyses the best technological strategy to be used for energy utilization and gives an overview of the several components that make up the solution. The energy crisis is among the primary problems we are currently facing. The use of energy-efficient equipment can help us conserve energy. We have BLDC fans because energy-efficient fans are one such measure that has a significant function in reducing the power consumption. It has a longer lifespan, is very compatible, and has linear torque-speed characteristics

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