SmartBLDCMotorIntegrationinConventional Fan Housing for Power Optimization

Prof.A.S.Chavhan[1], ShivaniKathar[2], VaishnaviShinde[3], PrajaktaZambre[4], ParthKamalja[5]

Professor, Department of Electrical Engineering, Pune, India [1]

Student, Department of Electrical Engineering, Pune, India[2345]

NBN Sinhgad Technical Institutes Campus, Pune, India

Abstract:*This project retrofits a traditional ceiling fan using a capacitor-run induction motor with a high-efficiency BLDC motor to reduce power consumption and enhance performance. By replacing the stator and rotor whileretaining the fan's outer housing, the system uses an L6235-based control circuit for efficient speed control and motor protection. Power usage dropped from 160W to 36W—over 75% savings. The retrofit also improved startup time, torque, noise, and temperature. This cost-effective solution supports sustainable upgrades and encourages scalable BLDC retrofit kits for wide adoption.*

Keywords:
BLDCMotor,EnergyEfficiency,L6235DriverIC,SensorlessControl,PowerConsumptionReduction, Smart Fan Technology, Brushless DC Conversion

I. INTRODUCTION

In the pursuit of energy-efficient and sustainable electrical appliances, the Brushless DC (BLDC) motor has emerged as a superior alternative to traditional single-phase induction motors commonly found in household fans. This project focuses on the complete transformation of a conventional ceiling or pedestal fan—originally driven by a capacitor-start single-phase AC motor—into a high-efficiency BLDC motor system.

Traditional fans typically utilize non-inductive motors that operate on AC power, where a capacitor is used to create a phase shift necessary for starting and running the motor. While this design is simple and cost-effective, it suffers from inherent inefficiencies, high power consumption, and limited speed control. With the increasing demand for smart and energy-saving appliances, the need for an efficient motor retrofit solution becomes critical.

This project involves a comprehensive modification that replaces the fan’s existing stator and rotor assembly with those suitable for a BLDC motor. In addition to mechanical changes, a custom electronic control circuit is designed and implemented to drive the motor efficiently. The controller includes a microcontroller-based or discrete-component-based driver capable of generating the necessary three-phase commutation signals and integrating features such as speed control, soft start, and overload protection.

The primary objective is to significantly reduce power consumption while maintaining or improving airflow performance and ensuring silent, reliable operation. By retrofitting a BLDC system into the existing fan housing, this project presents a practical, cost-effective pathway for upgrading legacy appliances and contributes to reducing the overall carbon footprint of domestic electrical consumption.

II. LITERATURE SURVEY

2.1 Energy Efficient Ceiling Fan using BLDC Motor (2015)

A brushless DC (BLDC) motor is a synchronous electric Motor powered by direct current (DC) electricity having an electronics commutation system, rather than a mechanical commutator and brushes. 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 is aims at the practical implementation of BLDC motor as a ceiling fan and also introduced different types of speed control method for BLDC fan. This fan is implemented with three different modes of operations-manual mode, auto mode, remote control mode. We can select the mode by using a mode selector switch. In each mode speed is controlled by different methods. When it is manual mode speed can be controlled by a potentiometer. If it is auto mode the speed is automatically changed depending on the room temperature, LM35 temperature sensor is used to sense the room temperature in auto mode. If remote control mode is selected the speed can be adjusted by using a remote controller. RF module-transmitter and receiver are used for remote control operation

2.2 Optimized design of permanent magnet brushless DC motor for ceiling fan applications (2021)

The objective of this research to design a compact electrical motor for a ceiling fan to save more electric power. Presently, single phase induction motor is used for ceiling fan application. Losses generated by single phase induction are more and hence efficiency is lower. In addition, overload is not handled by single phase induction motor whereas DC models can handle a lot of overload quite easily. In induction motor, the rotor frequency is lesser than stator frequency i.e rotor frequency is slip times the stator frequency. AC induction motor uses capacitor in anyone of its phases to excite and rotate the machine, so it is larger in size. In this paper, the axial flux type of permanent magnet machine configuration is selected to propose the optimum design of ceiling fan machine. The proposed configuration has single stator and single rotor for the axial flux permanent magnet Brushless Direct current Motor (BLDC) machine. By using the magnet software, the analysis of proposed machine has been done in terms of various aspects such as the induced voltage, phase current and air gap flux density.

2.3 AC-DC PFC Converter Fed BLDCM Ceiling Fan (2021)

An AC-DC power factor corrected converter (PFCC) fed brushless direct current motor (BLDCM) fan is presented with high-frequency transformer isolation. A front-end PFCC in series with a VSI (Voltage Source Inverter) is utilized to drive the BLDCM fan with enhanced PQI (Power Quality Indices) at the supply RMS voltage. The turn ratio of the isolation transformer is considered in such a way that the switch stress is minimum. The PFCC is designed in discontinuous conduction mode (DCM) of operation to get the natural power factor correction at the supply side. An auxiliary voltage of the HFT is utilized to handle the supply voltage fluctuation and to control the PFCC output voltage. The line frequency switching minimizes the inverter losses due to switching. The prime objective is to design the ceiling fan without using any sensor, low harmonics distortion, compact size, and minimum losses. It reduces the fan cost. Simulated results are shown to validate the design and performance of the fan system

2.4 Enhancement of Power-Quality in a BLDC Ceiling-Fan Powered by Unity-Power-Factor Zeta Converter (2023)

This paper presents a permanent magnet brushless direct current motor (PMBLDCM) ceiling-fan (CF) that operates on AC mains with a unity power factor (UPF). An AC-DC power-factor-corrected converter (PFCC) performs in discontinuous-conduction mode (DCM) to facilitate various merits such as an inherent UPF, reduced passive components size, stable operation, and required voltage control. The PMBLDCM ceiling fan speed is controlled by a smooth change in converter voltage output, and it helps to operate a voltage source inverter (VSI) at a fundamental frequency with low switching losses. This control maximizes efficiency of a ceiling fan. The THD (Total Harmonics Distortion) of a supply-current is reduced with a wide range of speed control and supply voltage fluctuations. A prototype of it is developed to validate the design and control. Its performance is compared with a conventional PMBLDCM ceiling fan. Test results are shown to verify the design of PFCC. The power quality indices (PQI) at input supply are meeting the IEC61000-3-2 standard.

III. METHODOLOGY

This section details the methodology and technical aspects of implementing a BLDC motor control system using the STMicroelectronics L6235 driver IC, which supports three-phase BLDC motors with Hall sensor feedback. The focus is on understanding how the circuit works and how each subsystem contributes to efficient motor control.

3.1 Power Supply and Bootstrap Circuit Configuration

The first essential part of the methodology lies in powering the L6235 driver IC and ensuring it can generate appropriate gate voltages for the high-side MOSFETs. The L6235 requires a DC supply voltage (VS) ranging from 8V to 52V, which powers both the internal logic and the motor windings. The circuit distinguishes between power ground and signal ground, which is crucial for noise isolation and safety

3.2 Three-Phase Motor Control with Hall Feedback Integration

The core of the methodology revolves around the control of a three-phase BLDC motor. This is done using a combination of sensor feedback, PWM control, and output driver stages in the L6235.

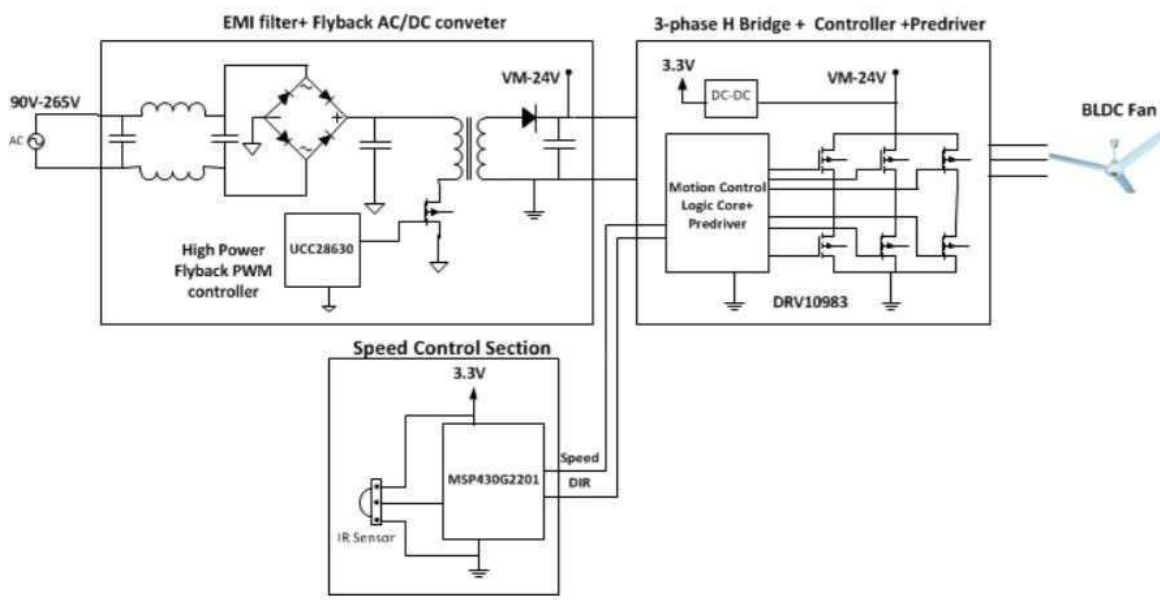
3.3 Control Inputs: Direction, Braking, and Enable Logic

The L6235 offers a variety of control inputs that allow for runtime operation control, including start/stop, direction control, and braking. These functionalities make the system suitable for custom fan applications, where user-defined modes like sleep, reverse airflow, and dynamic speed adjustment are needed.

3.4 Speed Control and Tacho Feedback Mechanism

Speed control in this setup is achieved using voltage control on the VREF pin (Pin 13) and supported by the TACHO (Pin 8) output, which provides feedback on rotor speed. This enables closed-loop or open-loop speed regulation.

BLOCK DIGRAM



CALCULATION

• Traditional Fan:

Power consumption: 80 watts

Daily consumption: 80W * 8 hours = 640 Wh = 0.64 kWh Annual consumption: 0.64 kWh/day * 365 days = 233.6 kWh Annual cost: 233.6 kWh * □7/kWh = □1635.2

• BLDC Fan:

Power consumption: 35 watts
Daily consumption: 35W * 8 hours = 280 Wh = 0.28 kWh Annual consumption: 0.28 kWh/day * 365 days = 102.2 kWh Annual cost: 102.2 kWh * ₹7/kWh = ₹715.4
Difference:
Annual savings: ₹1635.2 - ₹715.4 = ₹919.8 per fan

IV. CONCLUSION

The aim of this project was to successfully retrofit a conventional non-inductive capacitor-based ceiling fan with a Brushless DC (BLDC) motor setup, resulting in improved power efficiency, controllability, and reliability. The retrofit involved designing and implementing a custom motor driver circuit based on the L6235 IC, integrating it with a three-phase BLDC motor, and evaluating the fan's performance across various conditions.

This section presents the detailed results, compares performance metrics between the traditional fan and the retrofitted BLDC fan, analyzes the results, draws meaningful inferences, and concludes the overall effectiveness and practicality of this system.

V. FUTURE SCOPE

The successful conversion of a conventional AC fan to a BLDC-based system presents a powerful opportunity for industries, especially in the home appliance, HVAC, and energy efficiency sectors, to adopt and scale energy-efficient solutions.

Extends the lifecycle of existing appliances. Reduces e-waste and supports sustainability goals.

Enables widespread adoption in cost-sensitive markets

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