PROJECT ABSTRACT

Sensorless BLDC Motor Speed Controller using Back-EMF

An Arduino-based sensorless BLDC drive that commutates a 3-phase MOSFET bridge from back-EMF zero-crossing detection, with open-loop start-up ramp, PWM speed control and RPM display — delivered built-to-order with working prototype, firmware, wiring documentation, report, PPT and viva kit.

01. Title

Sensorless BLDC Motor Speed Controller using Back-EMF

02. Introduction / Background

BLDC motors dominate drones, EVs and appliances for their efficiency and brushless life — but their windings must be commutated electronically in exact sync with the rotor. The usual answer is Hall sensors; the sensorless answer exploits the motor as its own sensor: the un-energized winding generates back-EMF whose zero-crossing marks the commutation instant. Sensorless control reads this signal and commutates from it — cheaper and more robust, and a genuinely instructive problem because the drive must start the motor blind (no back-EMF at standstill) then hand over to closed-loop sensing. This project implements that full cycle: an Arduino drives a 3-phase MOSFET bridge, detects back-EMF zero-crossings against a virtual neutral, runs an open-loop start-up ramp, and provides PWM speed control with RPM display.

03. Problem Statement

Students learn BLDC theory but rarely implement commutation themselves, let alone the sensorless start-up problem: how to spin a motor with no position feedback, then transition to back-EMF sensing. The project addresses this by building a complete sensorless drive where the open-loop ramp, the handover, and closed-loop commutation are all observable — on the motor's behavior and the LCD — with overcurrent and stall protection included.

04. Objectives

- Commutate a 3-phase MOSFET bridge in six-step sequence from back-EMF zero-crossing detection.
- Implement an open-loop start-up ramp with handover to closed-loop sensorless control.

- Provide potentiometer-based PWM speed control and direction reversal.
- Display RPM (from commutation frequency), duty cycle and state on an LCD.
- Protect the drive with overcurrent limiting and stall/loss-of-feedback shutdown.
- Deliver a buyer-run tuning procedure plus the complete student kit.

05. Proposed Methodology

The methodology has four stages. (1) Sensing: the floating phase's back-EMF is divided down and compared against a virtual neutral built from the three phases. (2) Start-up: firmware runs a timed open-loop commutation ramp, accelerating until back-EMF is readable. (3) Closed loop: each zero-crossing schedules the next commutation 30 electrical degrees later; the potentiometer sets PWM duty cycle for speed. (4) Verification: the buyer tunes the ramp profile, confirms handover, calibrates the RPM readout and tests overcurrent/stall shutdown per the documented procedure.

06. System Architecture / Working

The drive chain is: DC supply -> 3-phase MOSFET bridge with gate drivers -> sensorless BLDC test motor. The sensing chain is: phase taps -> divider network + virtual neutral -> Arduino ADC/comparator (zero-cross detection) -> commutation scheduler in firmware. Current sensing feeds overcurrent protection; a potentiometer and direction switch are the user inputs; a 16x2 LCD shows RPM, duty cycle and fault state. A coupled demo load lets the examiner load the motor during the demo.

07. Hardware / Software Requirements

- Hardware: Arduino Uno/Nano, 3-phase MOSFET bridge with gate drivers, back-EMF sensing network (dividers + virtual neutral), current sensor, 16x2 LCD, potentiometer, direction switch, sensorless BLDC test motor with demo load.
- Software: Arduino IDE, C/C++ firmware (start-up ramp, zero-cross commutation, PWM, protections, LCD).
- Test: multimeter and tachometer/oscilloscope for the buyer's verification.

08. Expected Outcomes

A working sensorless BLDC drive that starts from standstill on its open-loop ramp, hands over to back-EMF commutation, and runs under smooth PWM speed control with live RPM display (speed range characterized by the buyer during setup as a design behavior, not a pre-claim); plus firmware, wiring docs, report, PPT and viva Q&A.

09. Applications

Sensorless BLDC control runs drone motors, cooling fans, pumps, power tools and e-bike hub motors — anywhere Hall sensors add cost or failure points. The bench drive teaches the commutation and start-up principles behind all of them.

10. Future Scope

Field-oriented control (FOC) for comparison; Hall-sensored mode as a fallback; closed-loop speed regulation with PI control; regenerative braking; and CAN/serial telemetry of drive state.