Poell~E Motor

A Novel Approach to Rotor Position Estimation and FOC Using Analog Hall Sensors

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Repository: https://github.com/Poell-E-Motor/poell-e-motor.git

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This white paper was created in co-creation with OpenAI's GPT-4, in continuous technical dialogue with the author. AI was used for analysis, simulation, visualization, structuring and writing support, under full human direction and authorship.

1. Executive Summary

This paper introduces a novel method for determining rotor position in Brushless DC (BLDC) motors using only two analog Hall effect sensors. The Poell~E Motor method demonstrates that it is possible to use a virtual sin/cos vector derived from two analog SS49E sensors to perform both sector-based commutation and enable Field-Oriented Control (FOC), while reducing hardware complexity.

2. Background & Motivation

Precise rotor position is essential for efficient BLDC motor control. Standard approaches include 3 digital Hall sensors for 6-step commutation, or high-resolution magnetic encoders for sinusoidal control. This paper explores whether 2 analog sensors, combined with signal processing, can replicate both roles.

3. Sensor Configuration & Core Idea

Two SS49E analog Hall sensors were simulated, placed at 0° and 100° mechanical offset. The motor has 24 poles (12 pole pairs) on the rotor and 18 stator slots. These sensors respond to alternating magnetic fields as the rotor spins. Figure 1 shows the simulated analog outputs from the sensors, which resemble sinusoids.

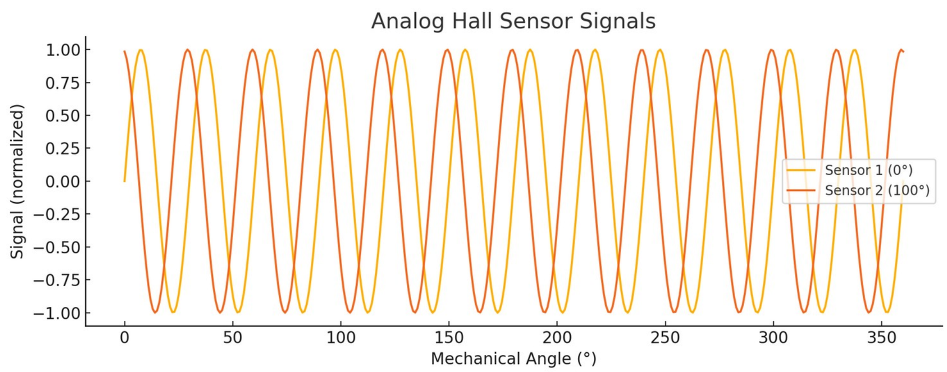

Figure 1: Simulated analog Hall sensor signals from two sensors 100° apart.

4. Digital Hall Emulation Using Thresholds

Analog signal voltages were segmented into discrete zones: South, Neutral, Middle, and North. Combining the two sensor states gave 9 possible combinations, of which only 6 are physically viable. These 6 states closely align with the 6-step commutation logic derived from digital Hall sensors.

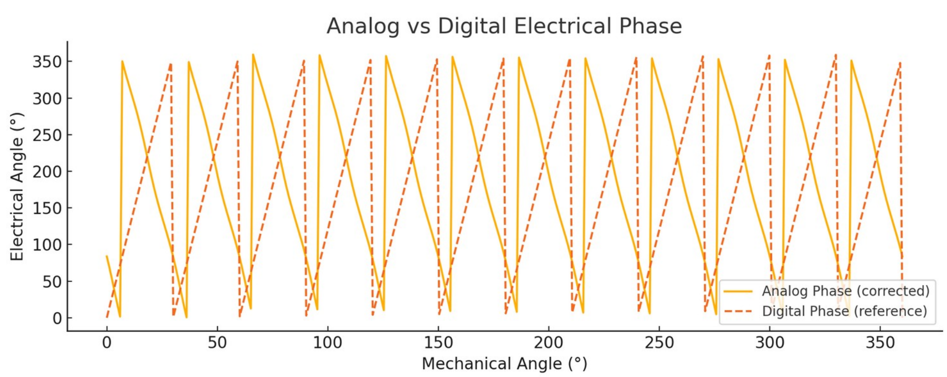

Figure 2: Comparison of analog and digital electrical phase sectors.

5. Virtual Angle Construction and Offset Correction

The analog signals were treated as sine and cosine components of a rotating magnetic vector. An electrical angle was derived using atan2(sensor2, sensor1), forming a continuous angular reference. Due to sensor placement, the angle required correction via vector rotation and linear transformation.

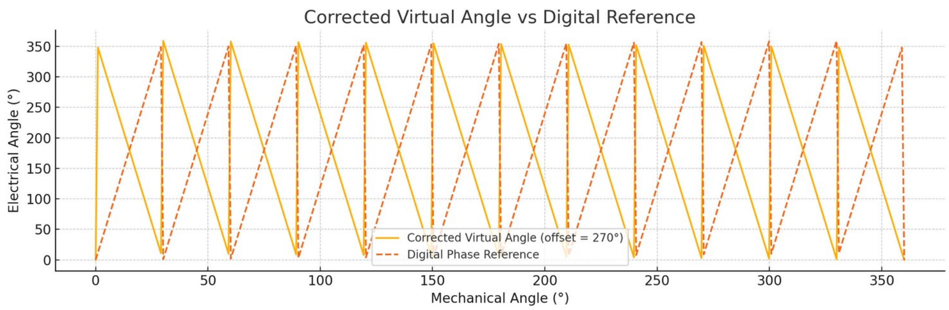

Figure 3: Corrected virtual angle compared to digital phase reference.

6. Sector Alignment Comparison

When comparing sectors derived from the virtual angle to traditional Hall logic, we observed partial overlap. This shows that the analog-based angle provides a consistent but differently-aligned reference.

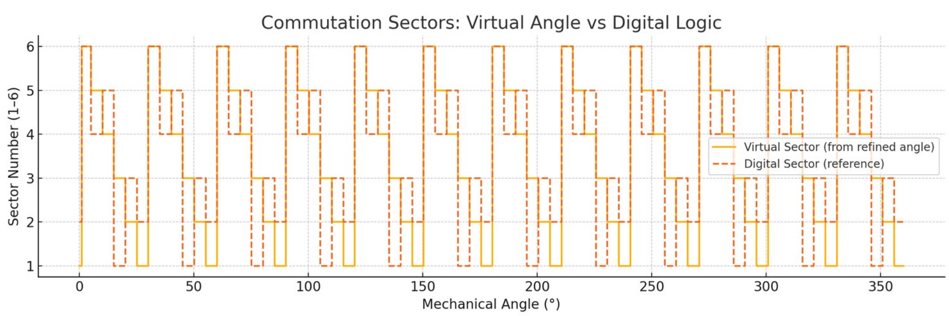

Figure 4: Sector comparison between analog and digital switching logic.

7. Sinusoidal Commutation and FOC Transition

The corrected virtual angle was used to generate sinusoidal references 120° apart, representing ideal 3-phase current waveforms for FOC. This confirms the feasibility of replacing encoders in FOC with a purely analog setup.

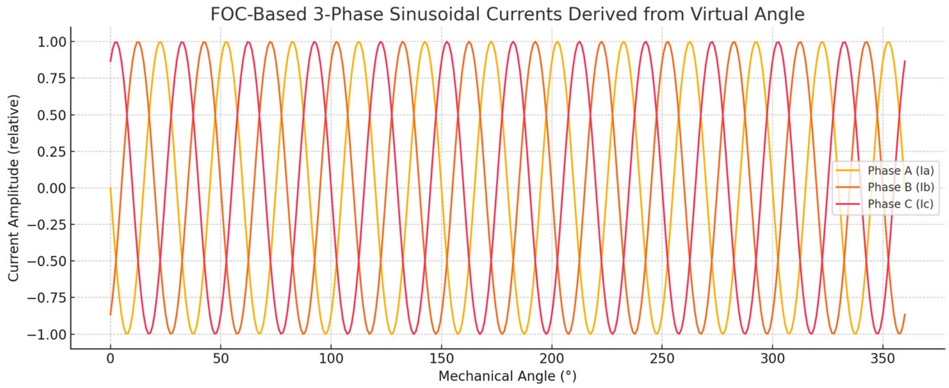

Figure 5: 3-phase sinusoidal current references derived from the virtual angle.

8. Licensing & Publication Statement

This work is released under the MIT License by Ralph Poell (Poell~E Motor) and made publicly available via GitHub:
https://github.com/Poell-E-Motor/poell-e-motor.git

This release establishes prior art and prevents restrictive patents on this method.

Appendix A: MIT License