

# Poell~E Motor

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**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>

License:       MIT

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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  $0^\circ$  and  $100^\circ$  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.

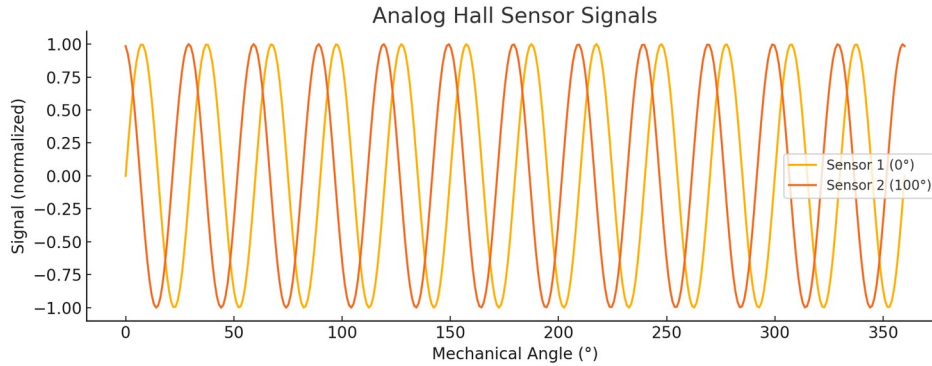


Figure 1: Simulated analog Hall sensor signals from two sensors  $100^\circ$  apart.

### 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.

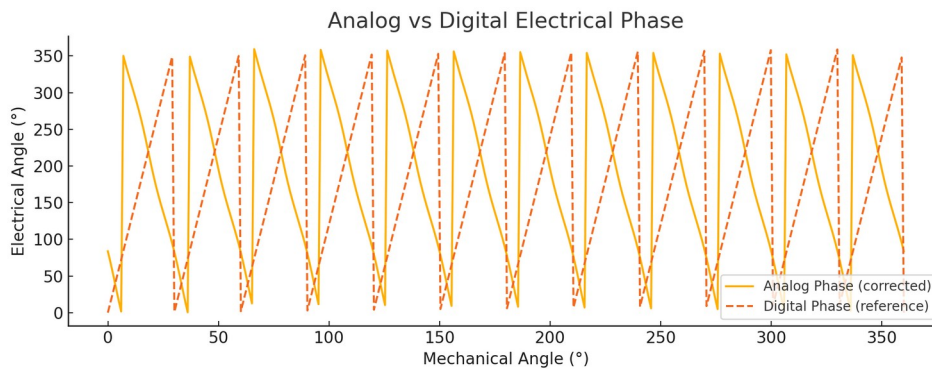


Figure 2: Comparison of analog and digital electrical phase sectors.

## 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  $\text{atan2}(\text{sensor2}, \text{sensor1})$ , forming a continuous angular reference. Due to sensor placement, the angle required correction via vector rotation and linear transformation.

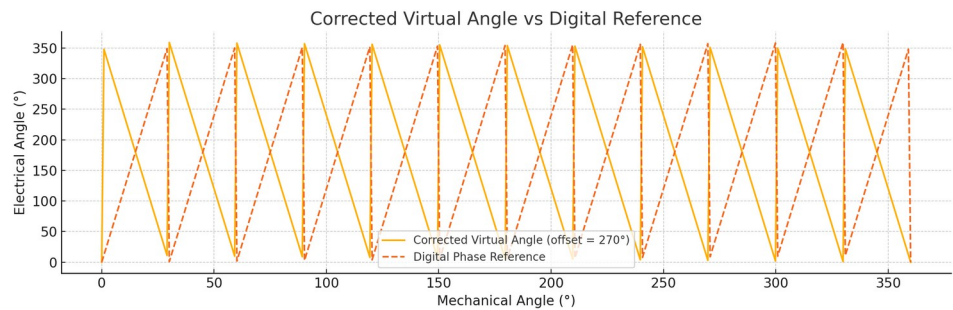


Figure 3: Corrected virtual angle compared to digital phase reference.

## 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.

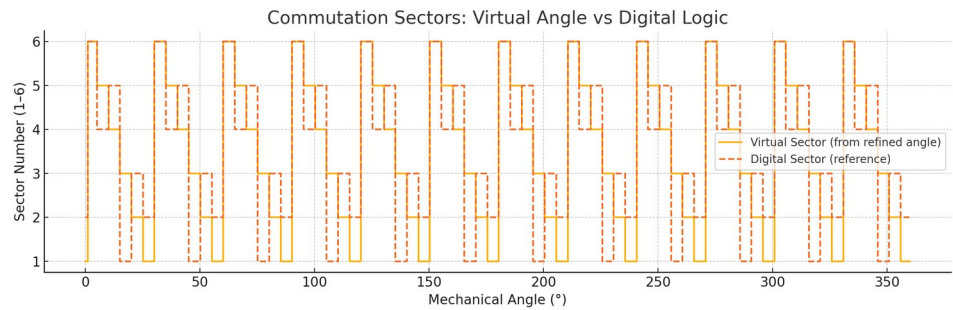


Figure 4: Sector comparison between analog and digital switching logic.

## 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.

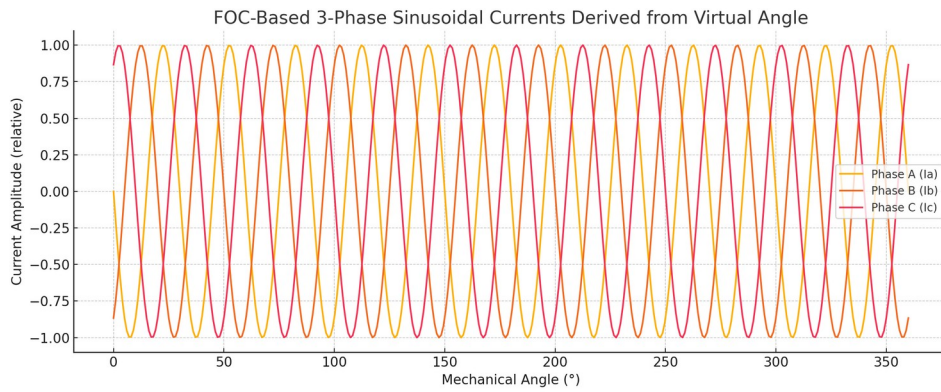


Figure 5: 3-phase sinusoidal current references derived from the virtual angle.

## 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

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