

ABSTRAK

Motor *Brushless DC* (BLDC) banyak diaplikasikan dalam industri karena efisiensi dan rasio torsi-terhadap-berat yang tinggi. Namun, metode pengendalian konvensional seperti komutasi enam langkah (*six-step commutation*) seringkali menghasilkan riak torsi (*torque ripple*) yang tinggi dan respon dinamis yang kurang halus. Penelitian ini bertujuan untuk merancang dan mengimplementasikan sistem kendali kecepatan dan arah putaran motor BLDC menggunakan metode *Field Oriented Control* (FOC) berbasis mikrokontroler STM32F411CEU6. Metode FOC dipilih karena kemampuannya mengendalikan torsi dan fluks secara terpisah melalui transformasi Clarke dan Park, sehingga menghasilkan putaran yang lebih stabil dan efisien. Sistem menggunakan sensor posisi magnetik AS5600 untuk umpan balik sudut rotor dan menerapkan algoritma *Space Vector Pulse Width Modulation* (SVPWM) untuk penggerakan inverter. Pengujian dilakukan pada variasi kecepatan 500, 700, dan 1200 RPM. Hasil penelitian menunjukkan bahwa sistem bekerja paling optimal pada kecepatan menengah (700 RPM) dengan tingkat kesalahan rata-rata (*mean absolute error*) hanya 0.64%. Pada kecepatan rendah (500 RPM), terjadi osilasi dengan standar deviasi 78.40 RPM, sedangkan pada kecepatan tinggi (1200 RPM) teramati fenomena *overshoot* sebesar 14.5% pada fase transisi. Selain itu, sistem berhasil melakukan pengendalian arah putaran (*forward-reverse*) secara digital tanpa perubahan perangkat keras. Penelitian ini menyimpulkan bahwa implementasi FOC pada mikrokontroler STM32 mampu meningkatkan kualitas pengendalian motor BLDC, meskipun optimasi parameter kontroler PI diperlukan untuk mengatasi ketidaklinieran pada kecepatan ekstrem.

Kata Kunci: Motor BLDC, *Field Oriented Control* (FOC), STM32F411, Kendali Kecepatan, SVPWM.

ABSTRACT

Brushless DC (BLDC) motors are widely applied in industry due to their high efficiency and torque-to-weight ratio. However, conventional control methods such as six-step commutation often produce high torque ripple and poor dynamic response. This study aims to design and implement a speed and direction control system for BLDC motors using the Field Oriented Control (FOC) method based on the STM32F411CEU6 microcontroller. The FOC method was chosen for its capability to control torque and flux independently through Clarke and Park transformations, resulting in smoother and more efficient rotation. The system utilizes an AS5600 magnetic position sensor for rotor angle feedback and applies the Space Vector Pulse Width Modulation (SVPWM) algorithm for inverter driving. Testing was conducted at speed variations of 500, 700, and 1200 RPM. The results showed that the system performed most optimally at medium speed (700 RPM) with a mean absolute error of only 0.64%. At low speed (500 RPM), oscillation occurred with a standard deviation of 78.40 RPM, while at high speed (1200 RPM), an overshoot phenomenon of 14.5% was observed during the transient phase. Additionally, the system successfully performed direction control (forward-reverse) digitally without hardware changes. This study concludes that the implementation of FOC on the STM32 microcontroller is able to improve BLDC motor control quality, although optimization of PI controller parameters is required to address non-linearities at extreme speeds

Keywords: *BLDC Motor, Field Oriented Control (FOC), STM32F411, Speed Control, SVPWM.*