

ABSTRAK

Panel surya memiliki karakteristik keluaran yang berubah-ubah akibat pengaruh kondisi lingkungan, terutama perubahan intensitas iradiasi matahari dan suhu, sehingga titik daya maksimum (*Maximum Power Point/MPP*) tidak selalu berada pada kondisi optimal. Permasalahan tersebut menyebabkan daya yang dapat diekstraksi dari panel surya menjadi tidak maksimal. Penelitian ini bertujuan untuk merancang dan mengimplementasikan sistem *Maximum Power Point Tracking* (MPPT) berbasis *Model Predictive Control* (MPC) pada sistem panel surya menggunakan *asynchronous buck converter* serta menganalisis kinerjanya dibandingkan metode *Perturb and Observe* (P&O). Sistem dirancang menggunakan panel surya *monocrystalline* 100 Wp, mikrokontroler ESP32, sensor INA219, dan *asynchronous buck converter* sebagai konverter DC–DC. Algoritma MPC diterapkan untuk menentukan nilai *duty cycle* secara prediktif berdasarkan model sistem *buck converter* sehingga titik operasi panel dapat dipertahankan mendekati titik daya maksimum (*Maximum Power Point/MPP*). Hasil pengujian menunjukkan bahwa sistem berhasil diimplementasikan secara *real-time* dan mampu menjalankan fungsi MPPT. Pada kondisi tunak, algoritma MPC menghasilkan *steady-state ripple* sebesar 7,147%, lebih rendah dibandingkan P&O sebesar 8,704%. Selain itu, pada pengujian perubahan iradiasi, MPC mampu meningkatkan daya rata-rata sebesar 9,81% serta meningkatkan energi yang dipanen sebesar 9,97% dibandingkan metode P&O. Berdasarkan hasil tersebut, algoritma MPC menunjukkan performa yang lebih baik dalam mempertahankan titik operasi panel surya dan meningkatkan optimasi daya pada berbagai kondisi operasi.

Kata Kunci: Panel Surya, *Maximum Power Point Tracking* (MPPT), *Model Predictive Control* (MPC), *Perturb and Observe* (P&O), *Asynchronous buck converter*.



ABSTRACT

Solar photovoltaic systems have variable output characteristics due to environmental conditions, particularly changes in solar irradiance and operating temperature, causing the maximum power point (MPP) to shift dynamically. This condition prevents photovoltaic panels from continuously operating at their optimal point, resulting in reduced extracted power. This research aims to design and implement a Model Predictive Control (MPC)-based Maximum Power Point Tracking (MPPT) system on a photovoltaic system using an asynchronous buck converter and evaluate its performance compared with the Perturb and Observe (P&O) method. The proposed system consists of a 100 Wp monocrystalline solar panel, ESP32 microcontroller, INA219 sensor, and asynchronous buck converter as a DC–DC power converter. The MPC algorithm is implemented to determine the optimal duty cycle based on the prediction model of the buck converter, allowing the photovoltaic operating point to remain close to the Maximum Power Point (MPP). Experimental results demonstrate that the proposed system was successfully implemented in real-time and capable of performing MPPT control. Under steady-state conditions, the MPC algorithm achieved a steady-state ripple of 7.147%, which was lower than the P&O algorithm at 8.704%. Furthermore, during irradiance variation testing, MPC improved the average output power by 9.81% and increased harvested energy by 9.97% compared with P&O. These results indicate that the MPC algorithm provides better performance in maintaining the photovoltaic operating point and optimizing power extraction under various operating conditions.

Keywords: *Solar Panel, Maximum Power Point Tracking (MPPT), Model Predictive Control (MPC), Perturb and Observe (P&O), Asynchronous buck converter.*

