INTISARI

Energi surya merupakan salah satu sumber energi terbarukan yang memiliki potensi besar untuk memenuhi kebutuhan listrik secara berkelanjutan. Sebagai sumber daya yang bersih dan melimpah, pemanfaatan energi matahari menjadi solusi strategis di tengah meningkatnya kebutuhan energi dan isu perubahan iklim. Karakteristik daya keluaran panel surya bersifat tidak stabil atau fluktuatif, dipengaruhi oleh perubahan intensitas penyinaran matahari (iradiasi) dan suhu lingkungan. Hal ini menyebabkan efisiensi konversi energi listrik pada sistem panel surya menjadi kurang optimal dan menimbulkan tantangan dalam penerapan sistem pembangkit berbasis energi surya.

Untuk mengatasi permasalahan tersebut, metode *Maximum Power Point Tracking* (MPPT) diterapkan guna menjaga operasi panel surya tetap berada pada titik daya maksimum atau *Maximum Power Point* (MPP). Dalam penelitian ini, algoritma *Perturb and Observe* (P&O) digunakan sebagai strategi pengendalian dalam sistem MPPT, dan diimplementasikan melalui simulasi menggunakan perangkat lunak MATLAB Simulink. Pengujian dilakukan dengan variasi iradiasi (200 hingga 1.000 W/m^2), suhu lingkungan (-10°C hingga 50°C), dan beban (0,1Ω hingga 0,51Ω). Kinerja sistem MPPT dievaluasi dengan membandingkan daya keluaran panel surya pada kondisi tanpa MPPT dan dengan MPPT.

Hasil simulasi menunjukkan bahwa penerapan algoritma P&O berhasil meningkatkan daya keluaran panel surya secara signifikan. Sistem MPPT yang diterapkan mampu meningkatkan efisiensi daya rata-rata sebesar 2–4%, dengan peningkatan efisiensi dari 86% menjadi 88% akibat variasi iradiasi, serta dari 80% menjadi 84% akibat perubahan beban. Secara keseluruhan, daya keluaran panel surya mengalami peningkatan rata-rata sebesar 50% dibandingkan sistem tanpa MPPT, dengan kenaikan daya sebesar 76,35% akibat perubahan iradiasi, 2,7% akibat suhu, dan 70,65% akibat perubahan beban.

Kata kunci: Panel Surya, MPPT, Algortima P&O, *Buck Converter*

ABSTRACT

Solar energy is one of the most promising renewable energy sources with great potential to meet electricity demands in a sustainable manner. As a clean and abundant resource, the utilization of solar energy presents a strategic solution amidst the growing energy needs and climate change issues. However, the output power characteristics of solar panels are inherently unstable and fluctuate due to variations in solar irradiance and ambient temperature. These fluctuations pose a significant challenge in achieving optimal energy conversion efficiency in photovoltaic systems.

To address this issue, the Maximum Power Point Tracking (MPPT) method is implemented to ensure that the solar panel operates consistently at its Maximum Power Point (MPP). In this study, the Perturb and Observe (P&O) algorithm is employed as a control strategy within the MPPT system, and its implementation is carried out through simulations using MATLAB Simulink. Testing is conducted under various conditions, including changes in irradiance (ranging from 200 to 1,000 W/m²), ambient temperature (from -10°C to 50°C), and load resistance (0.1Ω to 0.51Ω). The performance of the MPPT system is evaluated by comparing the solar panel's output power in both MPPT and non-MPPT conditions.

Simulation results demonstrate that the application of the P&O algorithm significantly improves the output power of the solar panel. The implemented MPPT system increases the average power efficiency by approximately 2–4%, with efficiency improving from 86% to 88% due to irradiance variation, and from 80% to 84% due to load changes. Overall, the solar panel's output power experiences an average increase of 50% compared to the non-MPPT system, with power gains of 76.35% due to irradiance variation, 2.7% due to temperature changes, and 70.65% due to load variation.

Key words: Solar Panel, MPPT, P&O Algorithm, Buck Converter