Performance Test of a Peltier Module-Based Cooling System with Automatic Temperature Control on Solar Panels

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ABSTRACT

The increase in the surface temperature of photovoltaic (PV) panels due to prolonged exposure to solar radiation can reduce their output power and energy conversion efficiency. This condition decreases the overall performance of photovoltaic panels, making a cooling system necessary to maintain the panel operating temperature at a lower level. This study aims to evaluate the performance of a Peltier module-based cooling system with automatic temperature control for a 100 Wp monocrystalline photovoltaic panel. An experimental method was employed by comparing the performance of a photovoltaic panel equipped with a cooling system and a photovoltaic panel without a cooling system. The cooling system consisted of two TEC1-12706 Peltier modules, a heatsink, a 12 V DC fan, a DS18B20 temperature sensor, a relay module, and an Arduino Uno microcontroller. The cooling system was programmed to activate automatically when the panel temperature reached 40°C and to deactivate when the temperature decreased to 35°C. Data were collected over a period of 10 days, from June 2 to June 11, 2026, at 30-minute intervals between 09:00 and 15:00 WIB. The observed parameters included solar irradiance, panel surface temperature, output voltage, output current, output power, and the energy consumption of the cooling system. The results showed that the cooling system operated automatically according to the predetermined temperature thresholds and successfully maintained the photovoltaic panel at a lower operating temperature than the panel without cooling. During the testing period, the temperature reduction varied depending on solar irradiance and environmental conditions, reaching a maximum difference of 12.2°C. This reduction demonstrates that the cooling system effectively minimized heat accumulation on the panel surface, resulting in improved operating conditions. Based on the findings, it can be concluded that the Peltier module-based cooling system with automatic temperature control operated reliably, reduced the surface temperature of the photovoltaic panel, and has the potential to serve as an effective alternative for maintaining the optimal operating temperature of photovoltaic panels under actual field conditions.

Keywords: *photovoltaic panel, Peltier module, Arduino Uno, automatic temperature control, cooling system.*