Understanding the factors that influence the charging performance of a stand-alone PV-LED system

By

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ABSTRACT

Photovoltaic technology is one of the most promising alternative technologies in the world. Although the photovoltaic technology has been exploited and used by some light systems for many years now, the utilization of photovoltaic power lighting systems has been limited because of low efficiency of photovoltaic cells, high initial cost, and questionable system reliability.

For stand-alone PV-LED lighting systems to enjoy widespread use, they have to become more efficient, reliable, and economical. Therefore, the goal of this thesis is to analyze a typical photovoltaic-powered LED lighting system and to investigate the parameters that could contribute to an enhanced performance.

The author chose the MPPT controller as a tool to achieve this goal. The verifications of hypotheses help one understand the influence of temperature and the effectiveness of the MPPT controller. With a suitable MPPT controller, a stand-alone PV-LED lighting system can not only improve its charge efficiency but also enhance its system operating time. The idea of an MPPT controller is to effectively use the potential power from the PV module instead of wasting it. A system manufacturer can easily improve system performance through a controller with the MPPT function using fractional voltage or other algorithms. Therefore, an optimized stand-alone PV-LED system can be achieved through the MPPT technique.

This thesis study confirmed a thermal characteristic of a silicon PV module and analyzed the effects of a controller with maximum power point tracking function to solve a potential problem that is commonly seen in the charge process of stand-alone PV-LED lighting systems—an energy-inefficient operating point. The concept is that at a given temperature and irradiance, there must be a maximum output power point in the PV module system. If the PV module cannot constantly be operated at this point, the output power of the PV module can be decreased. A systematic study was conducted to investigate the influence of temperature on a silicon PV module and the charge performance with maximum power point tracking function controller in a stand-alone PV-LED lighting system.

This study demonstrated that:

- With higher irradiance, there will be higher potential power and faster charging rate in a stand-alone PV-LED system.
- With higher temperature, there will be lower positional power and slower charging rate in a stand-alone PV-LED system.
- With MPPT controller, the charging power increases and enhances charging rate.
- The overall charge performance was improved by using maximum power point tracking function, though controller conversion efficiency decreased in the MPPT controller.