UNIVERSITI TEKNOLOGI MARA

HYBRID MPPT ALGORITHM FOR MISMATCH PHOTOVOLTAIC PANEL APPLICATION

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ABSTRACT

Photovoltaic (PV) systems require an active optimization system known as maximum power point tracking (MPPT) system. However, due to non-linearity of the *I-V* characteristic of solar cell, the tracking of the true maximum power point (MPP) can be very challenging. On the other hand, the presence of a non-ideal operating condition such as partial shading causes the *P-V* characteristic of the PV modules to have multiple peaks. The presence of multi peak tends to increase the chance of the conventional MPPT algorithms to inaccurately optimize the system to the local peak PV power, in despite of the global peak. Moreover, the implementation of different type of PV module on a PV panel causes the PV system to have very severe mismatched *I-V* and *P-V* characteristic that can cause imbalance distribution of voltage, current, and power. On the other hand, the implementation of conventional direct MPPT technique causes oscillation in MPP tracking due to the perturbative nature of the algorithms. Otherwise, the soft-computation MPPT methods by evolutionary algorithms such as Particle Swarm Optimization (PSO) algorithm require longer tracking time to prevent the false MPP tracking convergence. A distributed architecture of MPPT (DMPPT) system is proposed to solve the module mismatched, and partial shading issues. As for the MPPT technique, a novel hybrid MPPT algorithm is proposed to reduce the tracking time and oscillation, while increase the MPP tracking efficiency. Closed-loop PID control system is implemented to optimize the control speed, and accuracy of the MPPT system, along with PSO-based auto-tuning algorithm dedicated for the PID controller to provide adaptability with diverse hardware setup. MATLAB/Simulink is used to develop, test, optimize, and verify the proposed hybrid MPPT algorithm, and PSO-PID tuning method, before embedded in the MPPT system for the hardware implementation as a research product. Arduino platform is applied in hardware of the proposed MPPT system with Bluetooth connectivity. Comparative experimental study between the proposed hybrid MPPT algorithm, and PSO-MPPT algorithm shows that the proposed novel hybrid MPPT algorithm provides higher tracking performance in terms of speed of 600ms, and tracking efficiency of 99.4% in respect to the actual *P-V* curve, against 170s of tracking speed and 96.46% of efficiency of PSO-MPPT algorithm. From the comparative hardware test of MPPT architecture with mismatched PV module arrangement, the DMPPT are able to produce output with efficiency of 81.4%, while for CMPPT is 69.3%.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

For decades, fossil fuel is dominating the automotive, and power industries. Fossil fuel, coal, and their equivalents are known as one of major contributor to human's carbon footprint on the environment. Not only that it pollute the air, but also triggers climate change. With the recent initiative taken by Germany to stop the use of internal combustion engines in their parliamentary amendment by 2030 as reported by Reuters in [1], the renewable energy industry may flourish rapidly.

Photovoltaic (PV) generator is an integration of semiconductor cells interconnected together to be a PV module (as referred in the Figure 1.1). PV cells are current source generator whose converting energy from photons into electrical energy by the semiconductor device which is quite similar such as photodiodes, or phototransistors. Therefore, by having current-voltage (*I*-*V*) characteristics of semiconductor, the PV generator produces electrical power depends on light intensity (sun's irradiance), and its operating temperature. Conventionally, PV module comes with the specification based on the standard test condition (STC) with rated irradiance level, ψ of 1000W/m^2, and cell temperature, T_{cell} of 25˚C [2].The parameters such as open-circuit voltage, V_{OC}, short-circuit current, I_{SC}, voltage at maximum power, V_{MPP}, and current at maximum power, I_{MPP} is determined via testing in STC by the manufacturer. The effective load impedance, R_{MPP} in which that the PV module produces highest output power is determined by dividing V_{MPP} and I_{MPP}. Therefore, in order to extract maximum energy from the PV generator, the load must be equal to the R_{MPP}.