AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electrical Power and Machines Department

Enhancing the Maximum Power Point Tracking Technique for Photovoltaic System

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electrical Power and Machines Department)

By

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Bachelor of Science in Electrical Engineering

(Electrical Power and Machines Department)

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Statement

This thesis is submitted as a partial fulfillment of *Master of Science in Electrical Power and Machines* Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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ABSTRACT

In recent years, renewable energy sources have attracted a great deal of attention as a key solution to fossil fuel depletion. Photovoltaic (PV), which is the direct conversion of light into electricity, has emerged as one of the promising paths to achieve a transition to sustainable energy across the world. However, under different operating conditions, the voltage and maximum power produced from the PV array can vary.

Typical PV system consists of PV modules, DC-DC Converter and an MPPT. MPPT controls the DC-DC converter that acts as a coupling stage between PV module and load. A DC-DC converter is a device that transfers a DC supply's voltage from a level to another. Researchers face many challenges in designing converters with maximum efficiency, small size, reduced cost, and minimize switching losses. For the PV system applications, a conservative step-up (boost converter) can be used. This converter has a simple structure. The step-up (boost) converter is pulse controlled, when the duty cycle is near to hundred percent, the gain approaches infinity. But, practically, the static gain is restricted because of losses associated with the inductor, switch, diode, and capacitor.

This thesis aims to use a PV model for the simulation of photovoltaic arrays and thus to propose a method for tracking the maximum power point using alternative control methods for DC-DC converters. Besides, the thesis will focus on a comparison between the proposed method and Perturb and Observe (P&O) and Incremental Conductance (IC) methods that are used for maximum power point tracking. The proposed system consists of a PV model, a DC-DC converter, a VSC, a transformer, and a grid to simulate a real-life situation.

Furthermore, the P&O and IC as well as P&O and Cuckoo Search Algorithm (CSA) in combination will be investigated to reveal their effects on the general efficiency of the PV system. A Matlab/Simulink is utilized to show the impact of these methods on the PV system in various cases. According to the simulation results, using a combination of the above-mentioned maximum power point tracking methods (ICM-P&O/CSA-P&O), it provides a faster response under rapid changes in operating conditions than using conventional P&O and IC methods alone.

At the end of the thesis a practical experiment is presented which was conducted to verify one of the methods discussed in it.

Keywords

Maximum Power Point Tracking, Perturb and Observe, Conventional Incremental Conductance Method, Cuckoo search algorithm

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A	Ampere
E_g	Band Gap Energy
K_B	Boltzmann's Constant
T	Cell Temperature
P_d	Conduction loss of the diode
P_{SW}	Conduction loss of the switch
i, I	Current
I_{mp}	Current at MPP
℃	Degree Celsius
i_d	Diode Current
I_{sat}	Diode Saturation Current
v_d	Diode Voltage
V_d	Diode voltage drop
D	Duty Cycle
η	Efficiency
R_{sh}	Equivalent Resistors Parallel Resistor
R_S	Equivalent Resistors Series Resistor
GW	Giga Watt
a	Ideality Diode Factor
kW	Kilo Watt
i_{sh}	Leakage Current
P_{r_L}	loss of the inductor series resistance
N_s	Number Of Cells That Connected In Series
t_{off}	Off-time
t_{on}	On-time
V_{OC}	Open Circuit Voltage
$d_{optimum}$	Optimum Duty Cycle
$d_{overall}$	Overall Duty Cycle
I_{ph}	Photo Generated Current
$I_{ph.ref}$	Photo Generated Current at std.
P	Power
P_{mp}	Power at MPP
I_{PV}	PV Output Current
V_{PV}	PV Output Voltage

G_{ref}	Reference Solar Radiation
T_{ref}	Reference Temperature
I_{sc}	Short Circuit Current
K_o	Short-Circuit Coefficient Of Temperature at std.
G	Solar Radiation
V_{sw}	Switch voltage drop
V_T	Temperature Voltage
T_s	Total time duration
V	Volt
V_{mp}	Volt at MPP
W/m^2	Watt / Meter square

List of Abbreviations

AC	Alternating Current
ANN	Artificial Neural Network
$CSTE$	Concentration of Solar Thermal Energy
CCM	Continuous Conduction Mode
CSA	Cuckoo Search Algorithm
DC	Direct Current
DCM	Discontinuous Conduction Mode
DFIG	Doubly feed induction generator
$EPRT$	Energy Payback Time
$Fig.$	Figure
FLC	Fuzzy Logic Control
GA	Genetic Algorithm
HCM	Hill Climbing Method
IC	Incremental Conductance
ICM	Incremental Conductance Method
MPP	Maximum Power Point
$MPPT$	Maximum Power Point Tracking
$msec.$	Mile Second
PSO	Particle Swarm Optimization
PMSG	Permanent Magnet Synchronous Generator
$P\&O$	Perturb and Observe
PV	Photovoltaic
PWM	Pulse width modulation
RCC	Ripple Correlation Control
SDM	Single diode model
SSA	State-Space Averaging
SRFVC	Synchronous reference frame vector control
VSC	Voltage source converter