Cairo University

NEW APPROACH FOR MAXIMUM POWER POINT TRACKING IN PHOTOVOLTAIC SYSTEM

By

Eng. AHMED GAMAL EL DIN MOUSA SAIED

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

in
Electrical Power & Machines Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

Dr. Ahmed Mohamed Ibrahim

Assistant Professor
Electrical power and Machine Dept.
Faculty of Engineering
Cairo University

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Approved by the
Examining Committee

____
Assi. Prof. Dr. Ahmed Mohamed Ibrahim, Thesis Main Advisor

____
Prof. Dr. Essam El Din Aboul Zahab, Internal Examiner

____
Prof. Dr. Said Wahsh, External Examiner
- Prof. of Power Electronics- Electronics Research Institute

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Engineer's Name: AHMED GAMAL EL DIN MOUSA SAIED
Date of Birth: 05/11/1984
Nationality: Egyptian
E-mail: Folga11@yahoo.com
Phone: 01143497681 – 37789283
Address: 3 Mohammed Hassan st., Kafr Tohormos, Faisal, Giza
Registration Date: 1/10/2011
Awarding Date: / /2016
Degree: Master of Science
Department: Electrical Power and Machines Engineering

Supervisors:

Assi. Prof. Dr. Ahmed Mohamed Ibrahim

Examiners:

Prof. Dr. Said Wahsh (External examiner)
- Prof. of Power Electronics- Electronics Research Institute

Prof. Dr. Essam El Din Aboul Zahap (Internal examiner)
Assi. Prof. Dr. Ahmed Mohamed Ibrahim (Thesis main advisor)

Title of Thesis:

New Approach for Maximum Power Point Tracking in Photovoltaic System

Key Words:
Maximum power point tracking; perturbation and observation method; Incremental conductance method; renewable energy; photovoltaic

Summary:

Any photovoltaic solar generator (PVSG) can be efficiently utilized if it operates at its optimum operating point. Accordingly, many tracking algorithms for maximum power point tracking (MPPT) of photovoltaic (PV) modules had been developed. In the literature, the Perturbation and Observation (P&O) method and the Incremental Conductance (IC) method are the most widely used. Each of them has its advantages and disadvantages.

In this thesis, a MPPT algorithm method based on analysis of the mathematical relationship between the maximum power points and the corresponding currents at different operating conditions is presented. Several simulation results are provided to highlight the performance, effectiveness, advantages and disadvantages of the presented method compared to the conventional P&O and IC methods. Besides, a PV powered water pumping system is presented and discussed as an application of the different given MPPT techniques.

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Nomenclature *

(*According to alphabetic order)

AC	Alternative Current
a_{MPPT}	Accuracy of MPPT in percentage
C	Capacitor
$C^{\backslash}$	Proportional factor
C_{in}	The minimum value for the input decoupling capacitor
D	Duty cycle
DC	Direct Current
ε_{MPPT}	Relative tracking error in percentage
$\varepsilon_{MPPT,E}$	MPPT energetic error in percentage
ε_g	Band gap energy of the semiconductor
E	The motor back emf
g	Gravity acceleration
G	Irradiance in W/m^2
$G_{reference}$	Irradiance at 1000 W/m^2
G	Actual cell Irradiation
$\mathrm{G_{ref}}$	Standard cell Irradiation
h	Total pumping head in meters
Hz	Hertz
H	High
IC	Incremental conductance method
I_{MPP}	The current at the maximum power point
$I_{reference}$	Reference current calculated from $I_{MPP} = f(P_{\max})$ relation of certain power
I_{SC}	The short circuit current at STC in amperes
$IGBT$	Insulated Gate Bipolar Transistor
I	Current
I_a	The armature current
$I_{\max}$	The Maximum Current
I_{Sh}	Shunt current
IC	Incremental Conductance
I_{rr}	Irradiation Level
I_d	diode current
I_S	reverse saturation current
I_{MPP}	Current at the Maximum Power Point
I_L	Photo-light current
K	Boltzmann constant
$K^{\backslash}$	Proportional factor
k_T	Torque constant in Nm/A
K_E	voltage constant
K_P	Proportional gain
K_I	Integral gain

K_D	Derivative gain
K_i	short-circuit current/temperature coefficient (A/K)
L	Inductor
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
MOSFET	Metal Oxide semiconductor Field Effect
η	Efficiency
η_{MPPT}	Static efficiency in percentage
$\eta_{MPPT,E}$	MPPT energetic efficiency in percentage
N_S	Number of PV cells connected in series
N_P	Number of PV cells connected in parallel
n	Ideality factor
P&O	Perturb and observe method
PMDC	Permanent Magnet DC motor
P_U	Useful motor power in watts
PV	Photovoltaic
PVG	Photovoltaic generator
PVSG	Photovoltaic solar generator
ρ	Water density in kg/m^3
PMDCM	Permanent Magnet Direct Current Motor
P	Power
PI	Proportional Integral
PWM	Pulse Width Modulation
P&O	Perturb and Observe
$P_{\max}$	The Maximum Power
P_{MPP}	Power at the Maximum Power Point
P_U	Useful or net power applied on the motor
q	Electron charge
Q	Water flow rate in m^3/sec
R_{Load}	Load resistance in ohms
R_P	Parallel resistance in ohms
R_S	Series resistance in ohms
S_i	Silicon
SS_E	Sum of squares due to error
STC	Standard test conditions
S	The level of the photovoltaic irradiation
T	Operating temperature in degree Celsius
t	Simulation time in seconds
T_dn	Ramp down time in seconds
t_{dwell}	Dwell time between ramping up and down in seconds
T_{em}	Electromagnetic torque of the motor in Nm
T_f	Friction torque in Nm
t_up	Ramp up time in seconds
T_L	Load torque in Nm
T	Motor shaft torque
T_f	Fractional torque
T_{OP}	Actual cell temperature
T_{ref}	Standard cell temperature