ASSESSMENT OF HYBRID PHOTOVOLTAIC ARRAY MAXIMUM POWER POINT TRACKING METHOD

By

Yasmin Adel Abdel-Sattar Ali Hagag

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
GIZA, EGYPT
2017

ASSESSMENT OF HYBRID PHOTOVOLTAIC ARRAY MAXIMUM POWER POINT TRACKING METHOD

By

Yasmin Adel Abdel-Sattar Ali Hagag

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

Under the Supervision of

Dr. Ahmed Mohamed Ibrahim

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

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2017

ASSESSMENT OF HYBRID PHOTOVOLTAIC ARRAY MAXIMUM POWER POINT TRACKING METHOD

By

Yasmin Adel Abdel-Sattar Ali Hagag

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

Approved by the
Examining Committee

____

Associate. Prof. Dr. Ahmed Mohamed Ibrahim, Thesis Main Advisor

____

Prof. Dr. Essam El Din Aboul Zahap, Internal Examiner

____

Prof. Dr. Mostafa Abdel khalek Abu-Zeid, External Examiner

- Head of mechanical and electric organization , ministry of water resources and irrigation

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2017

Engineer's Name: Yasmin Adel Abdelsatar Ali Hagag
Date of Birth: 21/07./1982.
Nationality: Egyptian.
E-mail: Yasmin.adel.hagag@gmail.com
Phone: 01005392642-02 24710249
Address: Nasr city – Taqa street no 19

Registration Date: 11./10/2011
Awarding Date: …./…./2017
Degree: Master of Science
Department: Electrical Power & Machines Engineering

Supervisors:

Associate. Prof. Dr. Ahmed Mohamed Ibrahim

Examiners:

Prof. Dr. Mostafa Abdel khalek Abu-Zeid
(External examiner)
Prof. Dr. Essam El Din Aboul Zahap
(Internal examiner)
Associate. Prof. Dr. Ahmed Mohamed Ibrahim
(Thesis main advisor)

Title of Thesis:

ASSESSMENT OF HYBRID PHOTOVOLTAIC ARRAY MAXIMUM POWER POINT TRACKING METHOD

Key Words:
MPPT, PV system, Offline, Online, Hybrid methods

Summary:

The high demand for electricity and also the recent variation in the natural conditions, drag the intention about the need for another Source of energy, recently the use of solar energy has been emerging. Photovoltaic arrays have limited conversion efficiency and thus, a maximum power point tracking (MPPT) technique is an essential component in a PV system, The MPPT is the strategy which guarantees that the PV system under any climatic changes gives the most extreme accessible power.

This research adopts the most common categorization scheme of the MPPT techniques which is founded on two classifications: online and offline methods. This grouping is according to either the predefinition of operating points without system data update (offline methods) or continuous sampling of system variables, to update the PV module measurements (online methods).In these methods there is a trade-off between the simplicity, low cost from one side and accuracy from other side. Simple and low cost method can't track the maximum point accurately, other accurate tracking techniques are usually complex and higher cost is required, also these techniques need very high experienced end customer.

In order to get better method of MPPT techniques that guarantees the PV system under any climatic changes gives the most extreme available power with lower cost, a combination of both method offline and online was integrated as new hybrid method.

In this thesis an assessment of hybrid method is presented. A number of MPPT techniques have been modeled using MATLAB/Simulink program and their efficiencies were compared after simulating them under different climatic conditions, the radiation and rapid change in radiation were taken into account. The introduced hybrid method shows excellent efficiency and better performance at startup and reacts well to fast changes in climatic conditions.

Acknowledgments

My sincere appreciation and special thanks are due to Dr. Rameen Sayed AbdelTawab AbdelHady at the National Water Research Center. She has been working with me for the last five years; my first steps in the field of research were under her close supervision and technical guidance. She aided me in setting the work plan and the methodology. Her contribution was major through all the phases of the research and her support was decisive in the publication of a scientific paper related to research topic. Her useful comments and remarks lead me to finalize the thesis. Also, her experience in solving technical problems during the simulation process was of great help to me.

My faithful appreciation and special thanks are due to my supervisor, Assoc. Prof. Dr. Ahmed Mohamed Ibrahim, professor of Electrical Power and Machines Dept. Cairo University, Egypt, for giving me the honor of finishing my study under his supervision. His truthful comments encouragement are faithfully appreciated.

Also I would like to express my sincere thanks to my mother, father, husband, daughters and sisters, for their patience and continuous encouragement in study.
Special thanks to my friends Ghada Said and Nashwa Ahmed for their tremendous support.
Last but not least, no words of thanks and feelings are sufficient.

Table of Contents

List of Tables

List of Figures

Nomenclature

AC	Alternative Current (A)
AI	Artificial Intelligence
ANN	Artificial Neural Method
C_L	Converter capacitor (F)
D	Duty cycle
DC	Direct Current (A)
£$_g$	Band gap energy of the semiconductor
ε_{MPPT}	Relative tracking error in percentage
ESC	Extremum seeking control method
FF	Fill factor
FL	Fuzzy logic method
f	Frequency (HZ)
I	Current (A)
I_d	Diode current (A)
I_L	Photo-light current (A)
$I_{\max}$	Maximum Current (A)
I_{MPP}	Current at maximum power point (A)
IncCond	Incremental conductance method
I_O	Saturation current (A)
I_{PH}	Photo current (A)
I_{ref}	Reference current (A)
I_{SC}	Short circuit current (A)
I_{Sh}	Shunt current (A)
K	Boltzmann's const. $(1.4*10^{-23})$
K1,K2	Constant
L	Converter Inductance (H)
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
η	Efficiency
η_{max}	Max. efficiency
NB	Negative big
N_S	Number of PV cells connected in series
N_P	Number of PV cells connected in parallel
N	Diode ideality factor
OCV	Open Circuit voltage method
P&O	Perturb and observe method
PV	Photovoltaic
PVG	Photovoltaic generator
P	Power (W)
PWM	Pulse Width Modulation
$P_{\max}$	Maximum power (W)
P_{MPP}	Power at the Maximum Power Point (W)

P_{in}	Input power (W)
P_{out}	Output power (W)
P_T	Theoretical power (W)
PS	Positive small
PB	Positive big
PVG	Photo voltaic generator
q	Electron charge(1.6 *10^{-19})
RCC	Ripple correction control method
R_i	Input resistance (ohm)
R_o	Output resistance (ohm)
R_P	Parallel resistance (ohm)
R_S	Series resistance (ohm)
SCC	Short circuit current method
S_i	Silicon
R_{Sh}	Shunt resistance (ohm)
STC	Standard test conditions
S	The level of the photovoltaic irradiation (Watt/m^2)
T	Absolute temp. (K)
t	Simulation time (sec)
t_{off}	Time when chopper is open (sec)
t_{on}	Time when chopper is closed (sec)
V_O	Output voltage (V)
V_i	Input voltage (V)
V_{OC}	Open circuit voltage (V)
V	Voltage (V)
V_L	Inductor voltage (V)
V_t	Thermal voltage (V)
V_{MPP}	Voltage at maximum power point (V)
V_S	Source voltage (V)
V_{max}	Maximum voltage (V)
V_{ref}	Reference voltage (V)
ZE	Zero

List of publication

Assessment of a proposed hybrid photovoltaic array maximum power point tracking method

Yasmin Adel [a,b] , Rameen Abdelhady [a], Ahmed M. Ibrahim[b]

a: *National Research Center, Ministry of Water Resources and Irrigation, Egypt*

b: *Electrical Power and Machines Department, Cairo University, Egypt*

Science Direct magazine

30 July 2016; received in revised form 14 October 2016; accepted 19 October 2016Available online 5 December 2016

Abstract

Photovoltaic arrays have limited conversion efficiency and thus, a maximum power point tracking technique is an essential component in a PV system in pursuance of harvesting maximum power. Solar arrays exhibit nonlinear voltage-current characteristics that depend on solar radiations and temperatures. This makes the maximum power point tracking (MPPT) require prior prediction of the mentioned point in spite of the undeniable changes in the environment, for instance temperature and radiation. In this thesis an introduction and assessment of the different techniques of MPPT applied is presented. This research adopts the most common categorization scheme of the MPPT techniques which is founded on three classifications: online, offline and hybrid methods. This grouping is according to either the predefinition of operating points without system data update (offline methods) or continuous sampling of system variables, to update the PV module measurements (online methods). Whereas the introduced hybrid method is a combination of both.

Number of techniques from each class were simulated on a Sun Power SPR-305-WHT, which consists of 20 parallel strings and 5 series-connected solar modules per string, in MATLAB/Simulink environment so as to evaluate and compare the techniques performance. MATLAB/Simulink is selected, due to its reusability, extendibility, and flexibility in electrical power systems evaluation and analysis. Moreover, the hybrid method was simulated in two successive steps without pre-assumption of the output of the offline method. The results demonstrated the relevance of the hybrid method when applied to a photovoltaic system due to its good performance, fast response and less fluctuation, when subjected to sudden climatic change