Solar Energy 141 (2017) 182–202

Contents lists available at ScienceDirect

Solar Energy

journal homepage: www.elsevier.com/locate/solener

Review

Application of soft computing techniques for maximum power point tracking of SPV system

Dileep G. *, S.N. Singh

Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, Uttarakhand 247667, India

ARTICLE INFO

Article history:
Received 3 August 2016
Received in revised form 16 November 2016
Accepted 20 November 2016

Keywords:
Solar energy
MPPT
Soft computing
Partial shading
Photovoltaic

ABSTRACT

Conventional maximum power point tracking (MPPT) algorithms fails to track peak power from a solar photovoltaic panel (SPV) effectively under rapidly changing atmospheric and partial shading conditions (PSC). To track peak power more effectively under these conditions, low cost, powerful soft computing (SC) have been introduced by the researchers. Due to the ability to solve non-linear problems, flexibility and adaptive nature, SC based MPPT techniques can track peak power under varying atmospheric conditions. Various SC based MPPT techniques have been proposed by researchers till date. Comprehensive studies on all these techniques are not available. This work summarizes working principle of various SC-MPPT techniques and are compared each other based on the certain parameters like accuracy, tracking efficiency, SPV array dependency, convergence time, complexity of algorithm, hardware implementation, ability to handle PSC's and variables used. The information that is gathered and summarized in this paper will help researchers for future studies in this area.

Contents

* Corresponding author.
E-mail address: dileepmon2@gmail.com (G. Dileep).

http://dx.doi.org/10.1016/j.solener.2016.11.034
0038-092X/

Nomenclature

Abbreviations

A	diode ideality factor
ABC	artificial bee colony
ACO	ant colony optimization
AI	artificial intelligence
ANN	artificial neural networks
BN	Bayesian network
BP	back propagation
C	capacitor
CdTe	cadmium telluride
CIGS	copper indium gallium (di) selenide
CN	cognitive network
CPSO	complex method based PSO
D	diode
DC	direct current
DE	differential evolution
DPSO	dormant PSO
DSP	digital signal processor
E	economic
FCN	fuzzy cognitive network
FLC	fuzzy logic controller
FPGA	field programmable gate array
GA	genetic algorithm
GMPP	global maximum power point
GP	global peak
H	solar irradiance
HC	hill climbing
HFNN	Hopfield neural network
I	current
I_{c1} and I_{c2}	current through capacitor C_1 and C_2
I_d	diode current
I_{d1}	current flowing through diode D_1
I_{d2}	recombination current due the minority charge carriers flowing through diode D_2
I_{MPP}	current corresponding to MPP
I_o	load current
I_{ph}	photo generated current source
i_{pv}	solar cell generated and current
I_s	dark saturation current
I_{sc}	short circuit current
INC	incremental conductance
k	Boltzmann constant
K_{mT} and K_{mi}	current and temperature coefficients
L	inductor
LP	local peaks
MPP	maximum power point
MPPT	maximum power point tracking
NE	not economic
OPSO	orthogonal particle swarm optimization
PCU	power conditioning unit
PGS	SPV generating system
PI	proportional integral
PIC	peripheral interface controller
PID	proportional-integral-derivative
P_{MPP}	maximum power
P&O	perturb and observe
PSC	partial shading condition
PSO	particle swarm optimization
SPV	solar photo voltaic
Q	MOSFET switch
q	charge of the electron
RAM	random access memory
RCC	ripple correlation control
R_S	series resistance of solar panel
R_{sh}	shunt resistance of solar panel
SC	soft computing
SPV	solar photovoltaic panel
STC	standard test conditions
T	cell temperature
TC	tricore
T-S	Takagi-Sogeno
u	gate signal
V	voltage
V_{MPP}	voltage corresponding to MPP
V_o	load voltage
V_{oc}	open circuit voltage
v_{pv}	solar cell generated voltage

Symbol

η	efficiency
ms	milli seconds
%	percentage
s	seconds

1. Introduction

For the economical growth of a nation energy is an inevitable ingredient. As the world is growing day by day, demand of energy is also growing. To address the growing demand of energy, efforts have been made; to tap new energy sources and also increasing the energy tapped from the existing ones. Renewable energy tracking become one of the interesting area in recent years due increased energy demand all over the world and issues related to environment. Out of all renewable energy sources, solar energy has gained much more attention due to its inexhaustible nature, long life, zero running cost, low maintenance, pollution free and availability (Hassanien et al., 2016; Khare et al., 2016; Dawn et al., 2016; Grágeda et al., 2016; Sahoo, 2016; Kar et al., 2016; Kannan and Vakeesan, 2016; Ciriminna et al., 2016; Sinha and Chandel, 2015; Sher et al., 2015). In order to increase the efficiency of solar power tracking researches have been carried out in two directions: one in power conditioning units (PCU) and other in cell technology. Silicon mainly is used to manufacture solar cell in large scale. Almost 90% of world's solar cell production is from silicon (Lemus et al., 2016; Shalini et al., 2015; Sugathan et al., 2015; Xing et al., 2015). Mono crystalline silicon, polycrystalline silicon, amorphous silicon, copper indium gallium (di) selenide (CIGS) and cadmium telluride (CdTe) are few materials used to manufacture solar cells. Mono-crystalline solar cells offer efficiency around 15–18% and surface area of 7 m^2 is required to produce an output of 1 kW (Sengupta et al., 2016). Efficiency of poly crystalline solar cell is around 11–15% and surface area of 8 m^2 is required to produce an output of 1 kW (Mandal and Sharma, 2016). Amorphous silicon solar cells offer efficiency around 6–8% and surface area of 15 m^2 is required to produce an output of 1 kW (Makki et al., 2015). CIGS and CdTe are commercially used solar cells and they provide efficiency around 10–13% and surface area of 9 m^2 is required to produce an output of 1 kW (Ojo and Dharmadasa, 2016). Despite of the advancements in solar cell technology system cost is high and