Optimization of Maximum Power Point Tracking Algorithm using Artificial Intelligence

A.Nandha Kumar, R. Senthilkumar,T. Alex Stanley Raja, K. V. Santhoshkumar

***Abstract** — This paper highlights the maximum power point tracking algorithm for a photovoltaic array operating under different levels of solar irradiation using Particle Swarm Optimization (PSO). Further the photovoltaic array produces two or more maximum power points for different temperature conditions. Thus it is difficult to find the correct MPP using conventional method. In order to reduce this difficulty the MPP is obtained using Particle Swarm Optimization Technique. The feasibility of the new system is verified using MATLAB/SIMULINK simulation and its performance is analyzed.*

***Keywords-** Photovoltaic Array, MPPT, Particle Swarm Optimization, Boost Converter, Photo voltalic Inverter*

I. INTRODUCTION

Due to the duplicity of fossil fuels and increase in environmental pollution during the usage of fossil fuel for energy conversion an alternative energy sources is required to meet the demand. Hence the alternative energy is renewable energy sources like wind, solar, tidal, etc. Among these energy sources wind and solar are mostly popular because of the technology improvement in high power semiconductor devices. Photovoltaic sources are used in many places because of advantages like less maintenance, pollution free, simple operating mechanism, It also covers wide are of applications due to the increased efficiency of solar cells, manufacturing technology improvement in silicon cells and economy of operation [1].

In order to make the PV system to work efficiently it is connected to an intermediate power point tracking system. The maximum output cannot be obtained all the days. Hence in order to get maximum power output from the sun it is necessary to optimize the operating voltage of the PV arrays. To achieve this goal different types of MPPT algorithm are used. [2]- [3]. In paper [5] many techniques are compared for reference. However none of the paper suggests suitable technique for operation of solar panel under ideal atmospheric conditions. So this paper suggest about MPP tracking using PSO.

Initially PSO was developed by Eberhart and Kennedy in 1995. In this technique the populations of the particles are allowed to fly through the space at particular velocities. During each iteration the velocity of each particle is adjusted with respect to the pervious historical best position

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A.NandhaKumar, Department of Electrical and Electronics Engineering, Bannari Amman Institute of Technology, Sathyamangalam Tamil Nadu, India

R. Senthilkumar, Department of Electrical and Electronics Engineering,Bannari Amman Institute of Technology, Sathyamangalam Tamil Nadu,India

T. Alex Stanley Raja, Department of Electrical and Electronics Engineering, Bannari Amman Institute of Technology, Sathyamangalam Tamil Nadu,India

K. V. Santhoshkumar, Department of Electrical and Electronics Engineering,Bannari Amman Institute of Technology, Sathyamangalam Tamil Nadu,India

i.e. both for the particle itself and for the nearer neighborhood best position. User defined function is used to find the particle best and neighborhood best position. Thus each particle movement leads to a new optimal solution.

The converter section of PV system consists of VSI used to convert fixed DC to variable voltage ac supply and it is connected to the load i.e. with 1ϕ induction motor. In order to reduce the level of harmonic content in the output waveform of inverter multilevel inverter is used. Many inverter topologies are proposed with various modulation techniques during the last years [6].

Anew single phase three level inverter with full bridge configuration is used. In this inverter the switching pulses are generated using sinusoidal pulse width modulation technique. The three levels of the inverters are zero , +Vdc and – Vdc. However in this technique the harmonic content is reduced only to certain extent.

II. PHOTOVOLTAIC INVERTER

The new topology proposed for five level operation is shown in figure.

$$\boldsymbol{Vin} > Vg/2 \text{.........................} 1$$

$$\boldsymbol{Vin} > \frac{\sqrt{2Vg}}{2} \text{...........................} 2$$

An inductor filter Ls is used to filter the unwanted harmonics obtained form the inverter output. It should be with reduced harmonics. Thus to obtain pure sinusoidal current output sinusoidal PWM is used.

By comparing the high carrier frequency signal with low frequency sinusoidal PWM we can able to get the switching pulses of the inverter.

A.Operating Principle - PV Inverter

The auxiliary circuit which consists of switch S1 and four PN junction diode. The output of the auxiliary circuit is $+V_{pv}/2$ and $-V_{pv}/2$

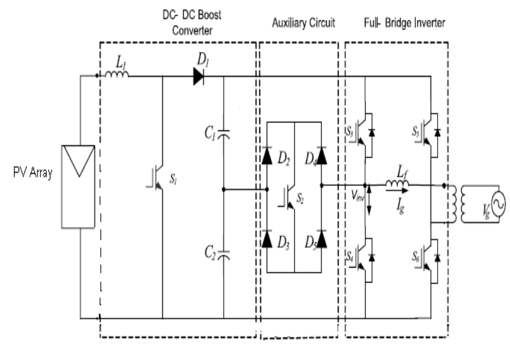

Fig.1 Proposed inverter topology for 1ϕ five level output

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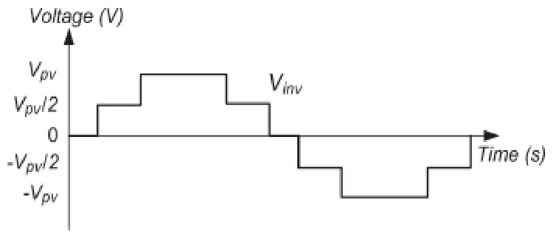

Fig.2 V_{inv} output voltage of invrter with five levels

The operating frequency of switches S4 and S5 is that of fundamental frequency but wheres switches S1 – S3 operates at the carrier signal frequency range. The switching pulses to the boost converter is fed through the MPPT controller. The switching patter is shown in figure.

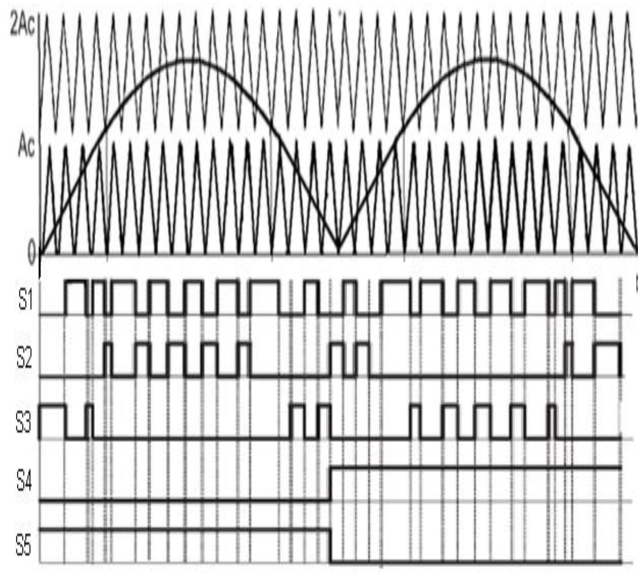

Fig.3 Pulses for switches S1 to S5

III. PROPOSED PARTICLE SWARM OPTIMIZATION FOR MPPT

A. Particle Swarm Optimization

The pso consists of many co-operative agents and these agents are responsible for sharing the information obtained during the process of searching with others. Each agents moves with a velocity of V_i^k, based on the local best position obtained earlier and global best position. The position and velocity of the agent is

$$v_i^{k+1} = wv_i^k + c_1 r_1 pbest_i + c_2 r_2 gbest \text{..................}3$$

$$s_i^{k+1} = s_i^k + v_i^{k+1} \text{..}4$$

$$pbest_i = s_i^k \text{..}5$$

$$f(s_i^k) > f(pbest_i) \text{...}6$$

here *f*function to be optimized.

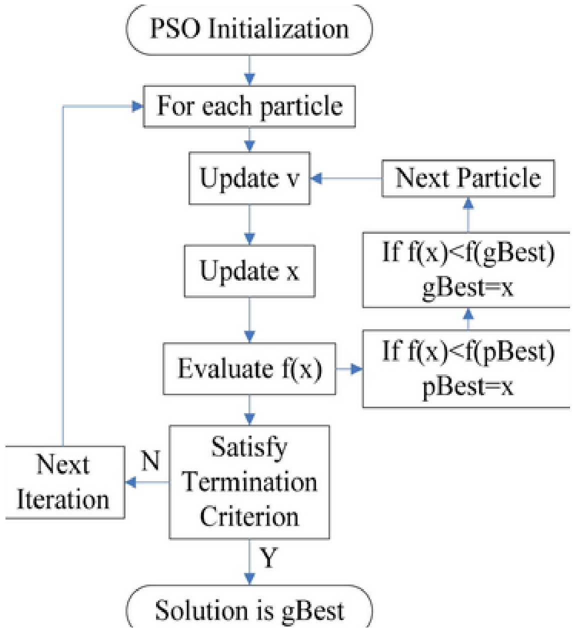

Fig. 4 Flowchart of PSO

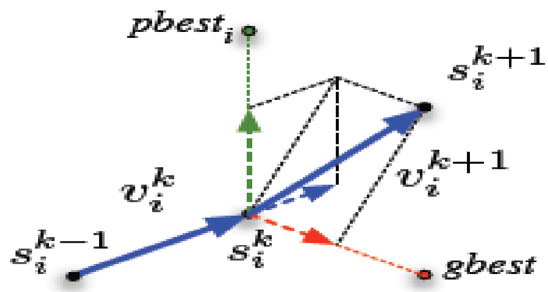

Fig.5 Functioning of PSO unit

B. Application : PSO to MPPT

Current sensor is used to sense the current and a voltage sensor is used. Since one sensor is used for many individual PV arrays it is called as multidimentional type MPPT control. The V_t of individual PV systems are represented as *N*- dimensional row vector as (7),

$$s^k = [V_1^k, V_2^k, \ldots\ldots\ldots.., V_N^k \text{.....................................}7$$

$$v^k = [V_1^k - V_1^{k-1}, V_2^k - V_2^{k-1}, \ldots\ldots\ldots.., V_N^k - V_N^{k-1} \text{........}8$$

f - generated power, = Σ power generated by eacharray.
Vout changes either as an order of measure power. M is the number of PSO agents.

$$\ldots\ldots \rightarrow s_1^k \rightarrow s_2^k \rightarrow \cdots s_M^k \text{.................................}9$$

$$\rightarrow s_1^{k+1} \rightarrow s_2^{k+2} \rightarrow \cdots \rightarrow s_M^{k+1} \rightarrow \cdots \text{...........}10$$

Realizations of the agents are done during the satisfaction of above two conditions.

IV. CLOSED LOOP CONTROL FOR PV INVERTER OPERATION

The digital PI control algorithm is used for feedback control The current injected into the 1 ϕ induction motor is iq The error between the iq and iref is reduced by the integratorin the PI controller. The error signal u is used to compare for obtaining the switching pulses. PI controller is given by,

$$u(t) = K_p e(t) + K_i \int_{\tau=0}^{t} e(\tau)\, d\tau$$

......…………………......14

Proportional term: $K_p e(t) = K_p e(k)$ ……………………15

Integral term: $K_i \int_{\tau=0}^{t} e(\tau)\, d\tau = K_i \sum_{i=0}^{k} \frac{h}{2}[e(i) + e(i-1)]$

………16

Time relationship: t = k* h

whereh assampling period and k as discrete-time index

For simplification, controller gains as $K_i' = K_i\,(h/2)$from which one can construct the discrete-timeas,

$$u(k) = K_p e(t) + K_i' \sum_{i=0}^{k} [e(i) + e(i-1)]$$

……………………..…17

The summation is expressed as arunning sum

$$sum(k) = sum(k-1) + [e(k) + e(k-1)]$$

……………………18

$$u(k) = K_p e(k) + K_i' \, sum(k)$$

………………………………19

Thus the controlled PWM pulses are injected into the inverter circuit in order to produce five level output voltage.

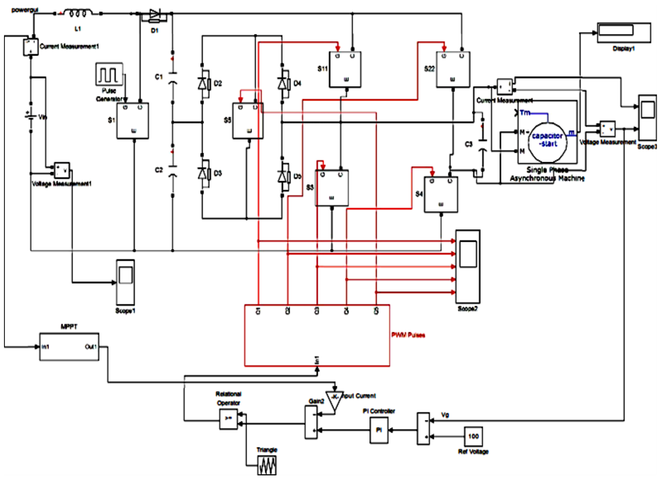

Fig.6 Block diagram of the PSO based proposed control algorithm for the photo voltaic inverter topology.

V. SIMULATION RESULTS

The simulation is carried out using MATLAB. The PSO algorithm parameters used in this paper are tabulated in Table I.Initial position of agent is selected randomly. The output of the PSO method applied to find maximum power point is ploted as shown in Fig.12.

From the output it is concluded that the value of output voltage is 199 V and the output current is 5 A.

w	0.4
Δv [V]	0.39
c_1	1.2
c_2	1.2
N	2
ΔP	0.15
M	3

Table 1 Pso Initial Agent Parameters

Sl. No.	V_1 [V]	V_2 [V]
1	0.2	0.2
2	0.8	0.5
3	0.5	0.8

Table2 Positioning of agents

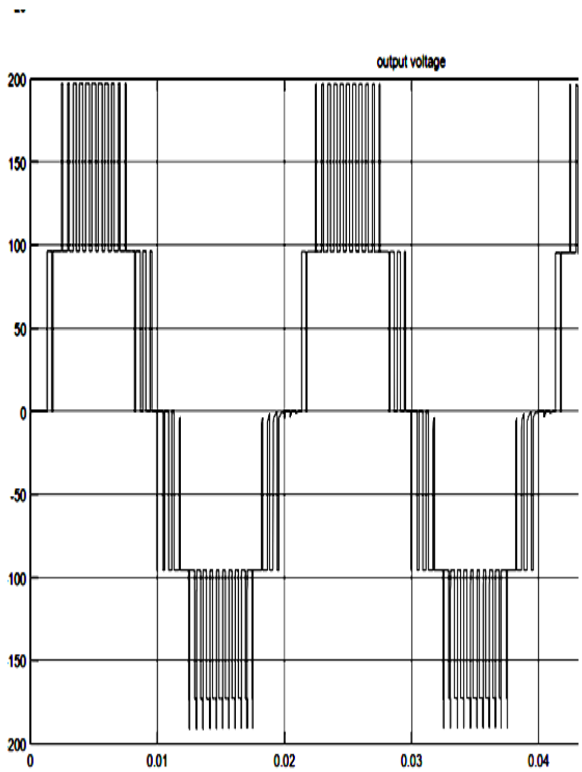

Fig.7Five level output voltage

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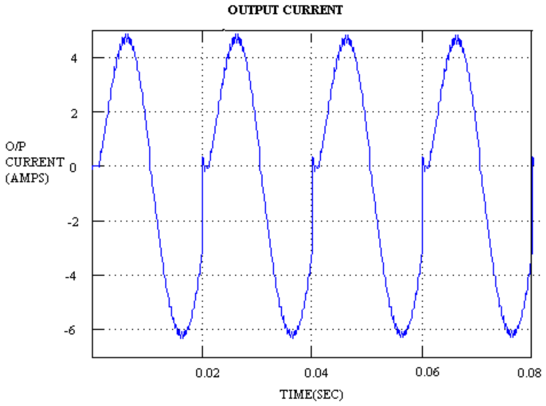

Fig.8 Output current

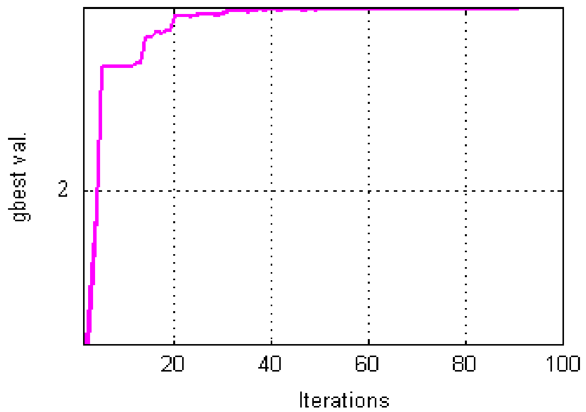

Fig.9Global Best Vs Iterations

DIMENSION	: 2
NUMBER OF PARTICLES USED	: 25
MODEL TYPE	: Terla model 1

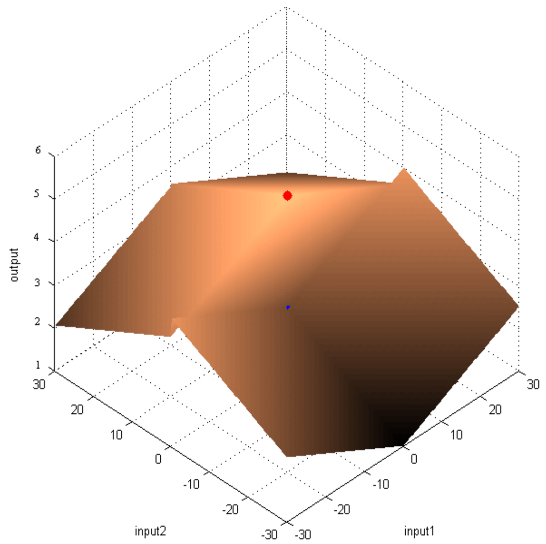

Fig.10 Output of MPPT using PSO

RED: Global Best
BLUE: Current positions

VI. CONCLUSION

Thus the MPPT algorithm is implemented. The algorithm is much easier and it consists of reduced switches.The simulation results show that optimized MPPT provides good reliability operation under changing atmospheric conditions.

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