Design of Intelligent Solar Power System Using PSO Based MPPT with Automatic Switching between ON grid and OFF Grid Connections

K.GAYATHRI, S.GOMATHI and T.SUGANYA

Abstract – ***Green energy generation is the most emerging research area in present scenario. Technologies like solar, wind, tidal are classified as renewable resources because of their sustained availability. PV systems are gaining much interest because of their increased efficiency. Solar energy fluctuates with the intensity of the radiated light. As a result the output power of the panel varies. This varying supply can neither be connected to grid nor used for load. Hence to obtain a maximum power, maximum power point technology (MPPT) is proposed. Existing algorithms like Perturb and Observe technique and Incremental Conductance proved to be less efficient in finding the optimal solution. Hence soft computing technique called Particle Swarm optimization algorithm (PSO) is proposed to find the maximum power. The proposed MPPT control algorithm is developed in MATLAB, which optimizes the panel voltage. Generated solar energy usually requires conversion to an alternating quantity, which is achieved using inverters. A three level inverter is implemented to obtain a harmonic less AC output. Simulation results show that the proposed algorithm is more efficient than the existing techniques.***

Keywords: Soft Computing technique, Particle Swarm optimization algorithm, Maximum power point tracking, three level inverter, Buck Boost DC-DC converter.

I. INTRODUCTION

The global energy consumption is increasing everyday due to increased population and advanced technologies. But due to unreliable electrical system, our country is facing severe power shortage problems. India and China are the two countries responsible for major consumption of energy. Due to Global warming concerns, there is a strong need to deploy clean energy sources and implement energy efficient solutions to meet future energy demand. Energy engineers all over the world are focusing on solar projects to increase the generation capacity. A solar system is made up of solar modules. Number of cells combines to form a module and these modules are in turn connected to form the PV system. The output DC voltage of the panel is then converted to desirable AC voltage for feeding excess power to the grid. Despite of advanced technologies, a grid connected PV system is always subjected to several complexities. Maximum Power Tracking algorithms were developed in past methodologies [1] to obtain continuous constant power. Comparison of various conventional MPPT algorithms is discussed in [2].

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Soft computing based algorithms were recently developed to obtain the global optimal solution under varying environmental conditions. The PSO [3] method is a simple and effective meta heuristic approach for obtaining optimal solution. It requires assignment of random weights and velocity vector. The proposed Particle Swarm Optimization algorithm (PSO) is a swarm behavior based technique and is relatively easier to develop.

The proposed work concentrates on designing DC-DC converter operated through the MPPT algorithm and a three level inverter to obtain AC supply. Section II explains PSO algorithm and its steps to find the optimal value. Section III explains the implementation of PSO technique to find the maximum power. Section IV the adopted converter and inverter topologies are discussed..

II. PARTICLE SWARM OPTIMIZATION ALGORITHM

Particle swarm optimization was first developed by Kenney and Eberhart [4].PSO is used to solve power system optimization problems. It provides optimal solution to problems like Economic load dispatch, Unit commitment, optimal reactive power dispatch etc., PSO is based on swarm intelligence to solve constrained optimization problems. The initial set of solution is called population and each member in the population is called as swarms [5]-[7].

PSO uses a initial solutions called swarms which are generated at random.

$$X=[X_1, X_2, X_3 \ldots Xn]$$

These particles move in the search space to find a good optimal solution. Particles find their search direction by using social and cognitive information. The best position that a particle has found is called pbest and the best position that any particle found is called gbest. The new position of a particle is found by the equation

$$X(t+1)=X(t)+V(t+1) \quad (2.1)$$

The formula to calculate the new velocity $V_i(t+1)$ as follows.

$$V_i(t+1) = w * V_i(t) + c_1 * rand(1) * (x_{pbesti} - x_i) + c_2 * rand(1) * (x_{gbesti} - x_i) \quad (2.2)$$

where w is the inertia weight, x_{pbesti} is the particle's pbest, x_{gbesti} is the position of the leader, c1 and c2 are the acceleration constants (user-defined) to control the influence of the cognitive and social elements respectively, rand() is a function that generates a uniform-distributed random real number between 0 and 1.

III. PSO BASED MPPT ALGORITHM

PSO based MPPT algorithm is developed to track the maximum power from the PV system. The output voltage and current from the panel varies according to insulation level. Since solar energy is time variant, a control algorithm

I_{ph}=photon current
I_{sat}=cell reverse saturation current
q = electron charge (1.6×10^{-19} C)
k = Boltzmann's constant (1.38×10^{-23} J/K)
A = ideality factor
I_{sh} = Short circuit current
V_{oc} = Open circuit voltage
T_{ref} = Reference temperature (K)
T = solar cell temperature (K)
S_{rad} = solar cell radiation
K = short circuit current temperature co efficient

Once value of current is computed, the corresponding voltage value that gives maximum power is computed from PSO. It finds the optimal voltage value to be produced by the

The block diagram of the proposed model is shown in the Figure 1.

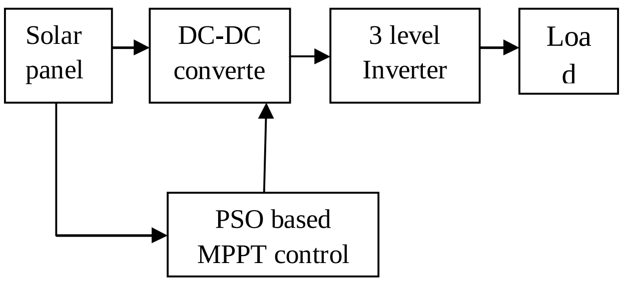

Figure 1: Block diagram for proposed model

Based on the steps discussed above, the algorithm finds the optimal V value that maximizes the objective function. The controller adjusts the duty ratio of Buck-Boost converter to get the required output voltage. Thus whole PV system's maximum power is tracked all the time and converted to desired AC value suitable for the load.

IV. POWER ELECTRONIC CIRCUITRY

The buck boost converter can either bucks or boosts the panel's DC voltage. The advantage of proposed inverter topology is that it produces AC quantity with reduced harmonic content and low switching losses. The converter is controlled through MPPT controller that is coded with PSO. The output voltage of a converter is adjusted as per the duty cycle. The output of the PV panel is connected to the inverter

is developed to keep in track the value of power which is maximum irrespective of time [8]. The following expressions prove that the panel's output current is directly proportional to the incident radiation and temperature.

$$I = n_p I_{ph} - n_p I_{sat}\left[\exp\left(\frac{qV}{kATn_s}\right) - 1\right] \quad (3.1)$$

$$I_{ph} = \left[I_{sh} + \frac{K}{1000}(T - T_{ref})\right] S_{rad} \quad (3.2)$$

$$I_{sat} = I_{ph} / (\exp((V_{oc} * q)/kAT) - 1) \quad (3.3)$$

n_p =number of cells in parallel connection
n_s = number of cells in series connection

Buck-Boost converter based on power value. The population set containing voltage values is initially chosen.

$$V = \{V_1, V_2, V_3, \dots\dots\dots\dots\dots V_{oc}\} \quad (3.4)$$

The fitness function is maximization function expressed as

$$f(x) = \max(P) \quad (3.5)$$

Where $P = (V * I)$
Thus

$$f(x) = \max(V * I) \quad (3.6)$$

via DC-DC buck boost converter. The buck boost converter's duty cycle is adjusted as per the MPPT algorithms optimal voltage value. Several converter topologies were used in the past decades [9]. Conventional boost or buck converters employ hard switching. This increases switching losses and thus reduces the overall efficiency [10]. Two stage systems consist of cascaded connections with increased number of switches. Power loss is high in such topologies.

The obtained DC voltage should be converted to a corresponding AC quantity. A general overview of different types of PV inverters is given in [11] and [12]. Here three level inverter configuration is employed for the conversion process. Switching losses are eliminated to a greater extent. Comparatively higher or lower output is obtained as per the load requirements. The proposed system is designed and implemented using three level inverter and it is simulated using MATLAB software

V. SIMULATION RESULTS

The algorithm and simulation circuits are developed in Mat lab environment. The efficiency is tested using different number of swarms and iterations. Convergence of the algorithm depends on velocity and random factors. Various optimal values for a module with 36 cells, open circuit voltage 21.75V and short circuit current 4.75A is tabulated below. PSO traps the global optimal value when radiation level is different due to environmental conditions. The various values of optimal voltage and power for each iteration are tabulated in the table 1, 2 and 3.

Table 1: Maximum power of the panel for radiation=300 W/m^2, I=1.0689Aand Table T: population=100 particles

Iterations	Optimal voltage (Volts)	Power (Watts)
30	16.7262	17.8786
60	16.7266	17.8787
100	16.7266	17.8786

Table 2: Maximum power of the panel for radiation=500 W/m^2,I=1.7849A and population=100 particles

Iterations	Optimal voltage (Volts)	Power (Watts)
30	17.2851	30.8515
60	17.2849	30.8514
100	17.2849	30.8514

Table 3: Maximum power of the panel for radiation=750 W/m^2 I=2.6812A and population=100 particles

Iterations	Optimal voltage (Volts)	Power(Watts)
30	17.7406	47.5655
60	17.7406	47.5655
100	17.7406	47.5655

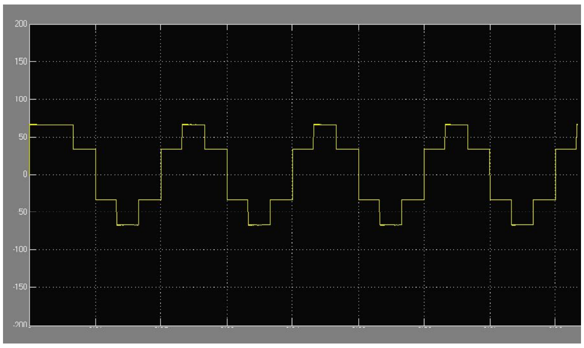

Fig 2: Current waveform of 3 level inverter

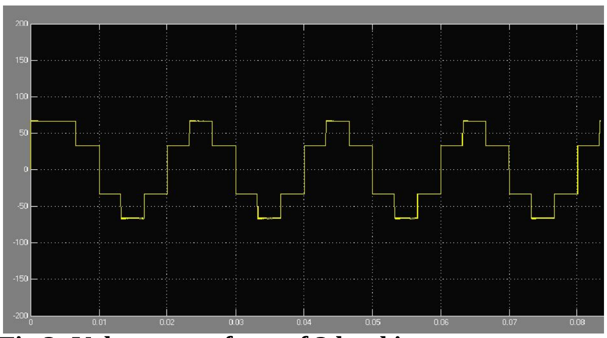

Fig 3: Voltage waveform of 3 level inverter

Current and voltage waveforms of the proposed inverter circuit are shown in Figure 2 and Figure 3. Circuit shows that less number of switching devices is used which reduces the switching losses. Thus the overall efficiency of the solar system is increased

VI. CONCLUSION

An optimization algorithm called Particle swarm Optimization Algorithm is proposed to obtain maximum power from the panel. The proposed algorithm effectively tracks the global optima of power value. Efficiency of the system is further increased by three level inverter configurations. The topology proves to be more efficient in both cost and gain. Losses are highly reduced with proposed inverter model. Existing MPPT algorithms like Perturb & Observe, Incremental Conductance fails to track the optimal value under partial shaded conditions. The proposed optimization technique overcomes this problem. Thus overall efficiency is improved with the proposed techniques.

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