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An Optimal Maximum Power Point Tracking using optimization algorithm in PV System

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ABSTRACT—*This paper proposes a New Harmony Search (HS) algorithm for improving the Optimization and performance of Maximum Power Point Tracking in PV System. The Harmony Search (HS) algorithm technique has been applied for multi-junction solar cell system. The solar panels are made up of different materials and give constant output from Boost converter. The main aim of Harmony Search (HS) algorithm is to find out duty cycle to the Boost converter to maintain constant output voltage irrespective of power produced by solar panels. This proposed harmony search algorithm (HSA) is also used to minimizing active power loss, voltage deviation and voltage stability index. A detailed simulation of the proposed method has been simulated in Matlab/Simulink. The simulation result shows that this design can be effectively realized in practical applications.*

Keywords— Maximum Power Point Tracking (MPPT); harmony search algorithm (HSA); Boost Converter.

I. INTRODUCTION

Photovoltaic (PV) energy is accepted as a popular source of non-conventional energy due to a number of benefits, particularly low operational cost and less pollution. Throughout the world, photovoltaic power generation is becoming increasingly popular due to a combination of factors: low maintenance, minimal wear and tear of components due to the absence of moving parts, lack of audible noise, absence of fuel cost, and pollution-free operation after installation. Small-scale PV installations are very popular as lighting and water pumping solutions in developing countries, remote villages, and small rural and urban communities. These systems are also commonly used in developed countries that have a considerable amount of solar irradiation. Solar PV Energy has enhanced interest in electrical applications, from the time when it is premeditated as a significantly unrestrained and mostly accessible energy supply. Among several renewable energy schemes, PV power generation structures are projected to play a consequential part as an unpolluted power electricity source since PV panels are suggested to install in roof-tops of house and porticos of buildings. The potency obtained from the PV panel is mainly dependent on atmospheric conditions like temperature and Irradiation. Ergo the efficiency of the solar cell is 20% is relatively very low. To amend the efficiency and reliability of the PV system several tracking systems are cited in the literature. Thus, to acquire consummate benefit of the solar energy it is vital to determine the peak point of the PV system.

The PV array has a only operating peak that can afford maximum power to the load. This peak is titled as the Maximum Power Point (MPP). This peak point has a nonlinear variation with irradiation and temperature. Hence to run the PV system at its MPP, the PV system ought to feature Maximum Power Point Tracking (MPPT) controller. MPPT control is coalesced with DC/DC boost converter will grant the PV array to engender the maximum available puissance, irrespective of the atmospheric conditions. Single junction solar cells utilize an element of the solar band depending upon apex of the band-gap of the particles utilized. On the contrary, multi junction (MJ) solar cells [1]-[2] formulated to find energy from a superior energy band of the solar group. Depending upon way of the links, two main forms of kineticism subsist: lateral multi-junction (LMJ) solar cells and vertical multi-junction (VMJ) solar cells.

A VMJ solar cell can get extortionate open circuit voltage and competencies accede with conventional single junction solar cells. As well, VMJ cells has the potential to get more benign efficiency by utilizing most recent material

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placements, concentrator methods and verbally express of the art manufacture technologies, while the usefulness of LMJ solar cell is generally dependent on expert diffraction process. Mundanely solar cells in a multi-junction configuration are annexed in series to shape a string, and multiple strings [4] are tied in parallel [3] to compose a panel. LMJ solar cells are capable to amalgamate to turn out a thoroughly synchronized system to procure gain of the multi-junction portion. The puissance outputs from the solar cells oscillate with irradiation, temperature and the load associated to it. So, maximum power point tracking (MPPT) is proximately an essentiality component of a capable solar cell system.

MPPT are relegated into three major groups. First group is called as conventional group namely Perturb and Observe and Incremental Conductance method. The draw backs of this group are its sluggish tracking faculty, steady state fluctuation at Maximum power point (MPP) and reduced competence. To surmount these drawbacks soft computing techniques are evolved. The techniques [7] that are included in this category are the Evolutionary Algorithms (EA), Fuzzy logic controller (FLC) and Artificial Neural Network (ANN). These groups withal have some shortcomings because of a few intricacies like it requires periodic training and it utilizes adscititious recollection will become arduous to implement in bio inspired methods The third group appeared under the type of Evolutionary computing, Particle swarm optimization (PSO), Bacterial foraging algorithm, Ant colony optimization (ACO) and Genetic Algorithm (GA) are the techniques included under this category. harmony search algorithm (HSA) predicated MPPT technique has been discussed in this paper where the obligation signal of four boost converters are modified on a customary substructure with a one MPPT controller to track the ecumenical maximum power point of the system.

II. HARMONY SEARCH ALGORITHM

Harmony Search Algorithm

The music improvisation is a process of searching for the better harmony by trying various combinations of pitches that should follow any of the following three rules [2]:

1. Playing any one pitch from the memory;

2. Playing an adjacent pitch of one pitch from the memory;

3. Playing a random pitch from the possible range.

This process is mimicked in each variable selection of the HS algorithm.

Similarly, it should follow any of the three rules below:

1. Choosing any value from the HS memory;

2. Choosing an adjacent value from the HS memory;

3. Choosing a random value from the possible value range.

The three rules in the HS algorithm are effectively directed using two essential parameters: harmony memory considering rate (HMCR) and pitch adjusting rate (PAR). Figure 2.1 shows the flowchart of the basic HS method, in which there are four principal steps involved.

Step 1. Initialize the HS memory (HM). The initial HM consists of a given number of randomly generated solutions to the optimization problems under consideration. For an n-dimension problem, an HM with the size of HMS can be represented as follows:

$$\mathrm{HM} = \begin{bmatrix} x_1^1, x_2^1, \ldots, x_n^1 \\ x_1^2, x_2^2, \ldots, x_n^2 \\ \vdots \\ x_1^{\mathrm{HMS}}, x_2^{\mathrm{HMS}}, \ldots, x_n^{\mathrm{HMS}} \end{bmatrix}. \qquad (2.1)$$

where $[x^i_1; x^i_2; \ldots; x^i_n]$ $(1; 2; \ldots; \mathrm{HMS})$ is a solution candidate. HMS is typically set to be between 50 and 100.

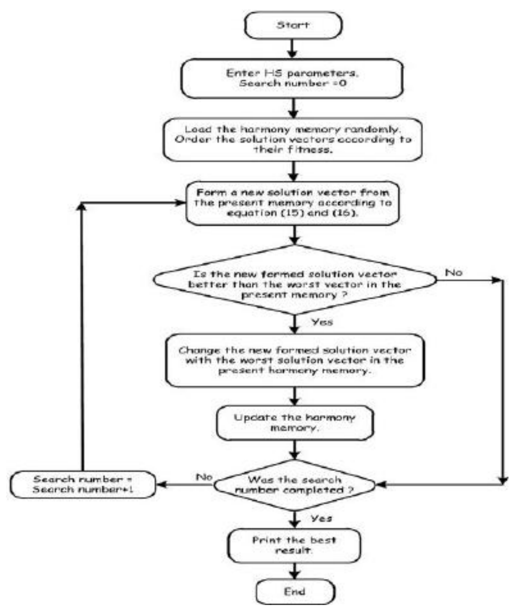

Fig. 2.1 Harmony Search (HS) flow chart

Step 2. Improvise a new solution $(x'_1; x'_2; \ldots; x'_n)$ from the HM. Each component of this solution, x'_j, is obtained based on the HMCR. The HMCR is defined as the probability of selecting a component from the present HM members, and

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1-HMCR is, therefore, the probability of generating it randomly. If x'_j comes from the HM, it is chosen from the j^{th} dimension of a random HM member, and it can be further mutated according to the PAR. The PAR determines the probability of a candidate from the HM to be mutated. Obviously, the improvisation of (x'_1; x'_2; . . .; x'_n) is rather similar to the production of the offspring in the genetic algorithm (GA) [4, 5] with the mutation and crossover operations.

However, the GA creates fresh chromosomes using only one (mutation) or two (simple crossover) existing ones, while the generation of new solutions in the HS method makes full use of all the HM members.

Step 3. Update the HM. The new solution from Step 2 is evaluated. If it yields a better fitness than that of the worst member in the HM, it will replace that one. Otherwise, it is eliminated.

Step 4. Repeat Step 2 to Step 3 until a preset termination criterion, e.g., the maximal number of iterations, is met.

Apparently, the HMCR and PAR are two basic parameters in the HS algorithm, which control the component of solutions and even affect convergence speed. The former is used to set the probability of utilizing the historic information stored in the HM. For example, 0.9 indicates that each component of a new solution will be chosen from the HM with 90 % probability, and 10 % probability from the entire feasible range. Each component of the solution is subject to whether it should be pitch-adjusted, which is determined by PAR. 1-PAR means the rate of doing nothing. For example, a PAR of 0.3 indicates that the neighboring value will be chosen with 30 % probability.

Similar to the GA, particle swarm optimization (PSO) [6–8], and differential evolution (DE) [9, 10], the HS method is a random search technique. It does not require any prior domain information, such as the gradient of the objective functions. However, different from those population-based evolutionary approaches, it only utilizes a single search memory to evolve. Therefore, the HS method has the characteristics of algorithm simplicity. On the other hand, it occupies some inherent drawbacks, e.g., weak local search ability. In the following two chapters, the comparisons between the HS and other NIC optimization algorithms and the variations of the HS will be discussed individually.

The proposed system consists of four PV modules and requires four MPPT trackers. To reduce the cost and computation time only one MPPT tracker is used in this method. The PSO algorithm is applied to update the duty cycle of DC-DC Converters by tracking the global maximum point with continually update the position and velocity. Boost converters are connected in series to share a common load as shown in Fig.2. In this system the purpose of PSO is to generate duty cycles dc (1), dc (2), dc (3) and dc (4) individually to each Boost converter to give determined output.

III. SIMULATION RESULTS

The model consists of a DC-DC Boost converter operated with switching frequency of 5 KHz. According to the specifications of the converter it can operate with voltage ranges from 0 to 200V at each input of the converters. In the proposed system solar panels with different materials are used. Here four panels is made up of four different materials like GaInAsp, GaInp, GaInAs, GaAs and it is connected to seperate Boost converter.

The simulation results of the PV system using PSO optimization technique has been shown in Fig.3. Simulation results depicts that PSO based MPPT algorithm can rapidly and precisely determine the maximum power of each modules and the system accomplished a accurate sense of the maximum power output.

Comparisons of converter outputs using PSO technique for different Insolation are shown in Table II.

It is noted that the temperature has been same for all the four materials and the Insolation value changes from 800 to 1000 W/m^2 and the results are displayed in table. Irrespective of the irradiation the proposed PSO has been track the maximum point has been shown in Table II and it gives corresponding duty cycle to the converters which are not possible by other MPPT techniques. PSO method has certain merits when compared to other techniques they are listed as follows, Simple structure, Easy Execution and has a very fast convergence speed to the preferred solution and it has very high tracking speed.

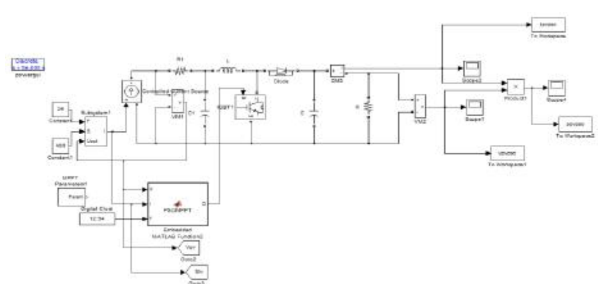

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Fig. 2. Schematic diagram of proposed system with PSO Algorithm

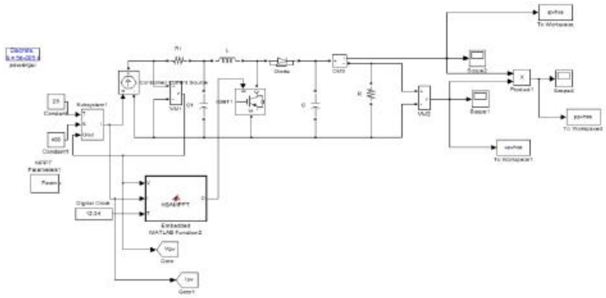

Fig. 3. Schematic diagram of proposed system with HSA Algorithm

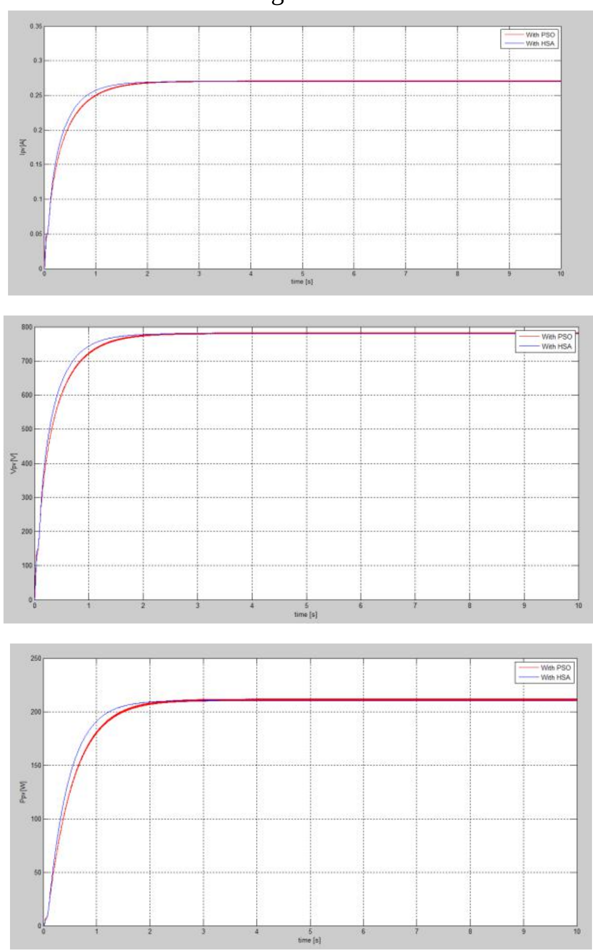

Fig. 3. Simulation results of Voltage, Current and power tracked using PSO & HSA algorithm.

IV. CONCLUSION

Particle Swarm Optimization (PSO) and Harmony Search Optimization (HSA) technique with an efficient duty cycle initialization has been demonstrated in this paper. The Proposed method HSA has been tested under unvarying and partially shaded environmental conditions. Based on simulation results the following conclusion was obtained. HSA method was found to have good tracking power even under partially shaded and varying atmospheric conditions.

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