PSO-GSA Based MPPT Algorithm for Photovoltaic Systems

Gazia Manzoor, Kamal Kant Sharma, Er.Satyanand vishwakarma

ABSTRACT--- This paper describes the maximum power point tracking[MPPT] technique for a single diode model based solar cell array module using the hybrid combination of perturb-observe and PSO-GSA optimization algorithm under varying environmental conditions. The proposed method sorted out the initial starting point problem in which perturb-observe takes some time in achieving Maximum power point and also shows fluctuated power when there is partial shading in the solar array. A hybrid of PSOGSA optimization algorithm is used which provides effective options of duty cycle for the MOSFET switch used in the buck booster circuit using the current and previous power changes along with voltage changes in the system. The proposed control method utilizes less number of iterations to optimize the maximum power point power value as compared to traditional particle swarm optimization (PSO) technique. The whole system is simulated using MATLAB/SIMULINK platform and has been compared with the conventional Particle Swarm Optimization algorithm under ambient conditions.

Keywords—Particle swarm optimization, perturb & Observe, MPPT, PSO-GSA etc.

I. INTRODUCTION

The P–V property of a photovoltaic (PV) element gives its optimal operational point, it is the point where maximum power can be distributed; that is recognized as the maximum power point (MPP). MPP depends upon the load impedance and whether condition however is not constant. Consequently, for a Photovoltaic scheme to retain effective process of the PVS boards at their maximum power point, MPPT techniques are essentially used [1], [2]. In recent times, numerous writers presented diverse descriptions intended for the complications linked through MPPT controller. A number of MPPT approaches are advanced up to now, fluctuating from the basic to the compound and reliant on the meteorological conditions and the switch policies implemented. Amongst them, there are the Incremental Conductance (IncCond) method [3], [4] and P&O method [1] & [5]. The procedures ensure the benefit of functioning autonomously, as information of PV producer features are not perilous. Though these approaches are modest to run [6], these are incapable to path the MPP perfectly in conditions wherever stages of solar energy are altering promptly. In addition, they could not work the scheme at the MPP in partially shading conditions (PSC), since they scare distinction among its global peak (GP) and local MPP[7][8]. A PVS during PSC in [9] demonstrating the usage of a predictable MPPT process in a fraction of shadow situations can consequence in noteworthy power fatalities. Conferring to [10], the effectiveness of MPPT regulators is compact in PSC, as maximum MPPT regulators work like here is merely single point where the PV unit could yield full power in the series of Power Voltage characteristic. Though, once Partial shading condition arises, the Power voltage characteristic turn out to be further multifaceted, revealing numerous peaks, that consecutively upset the presentation of the regulator, dropping the complete output power of the structure accordingly[11], [6]. In recent times, abundant improved MPPT approaches are offered in the collected works to confirm the precise tracing of Maximum power point, to increase vibrant scheme reaction & minimise the method hardware [12], [13]. The approaches vary in the convolution, accurateness, and speed. Although tracing was completed flawlessly by these approaches, the dynamic reaction rate of the scheme would be still small [2], [11], [9]. An another optimization method implemented to the MPP regulator of a PVS, functioning in PSC, in the Particle Swarm Optimization (PSO) procedure [14], [9][15].

II. RELATED WORK

In 2009, Masafumi Miyatakehas offered a new MPPT process by a PSO method to regulate numerous PV collections through single duo of current and voltage sensors. Since the planned system is a multi-dimensional based method, this is competent to discover the universal MPP level in composite fractional shading situations [13].After that ,Zainal Salam et al (2012) presented a PSO using the competence of straight duty series to path the MPP of a PV scheme. [9]. Then, Kashif Ishaque et al (2013) planned a DPSO technique to path the MPP of a PV scheme. The DPSO significantly make straight forward the switch arrangement of the MPPT through eliminating the arbitrary amount and speeding up measurements factors of the conventional PSO[14]. Further in 2014, Kinattingal Sundareswaran et al suggested a different method founded on ABC for GMPP tracing in a PV power production scheme. Arithmetical model ssupported on two dissimilar outlines through variable shading forms evidently prove the upgraded presentation of the suggested procedure in contrast to the current approaches of PSO and EPO [6]. Moreover, H. Renaudineau et al (2014) recommended a worldwide optimization policy implemented to a dispersed PV

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Gazia Manzoor, Department of Electrical Engineering Chandigarh university Punjab, India (E-mail: ergaziaqadri@gmail.com)

Dr. Kamal Kant Sharma Department of Electrical Engineering Chandigarh university Punjab, India (E-mail: kamalkant.ee@cumail.in)

Er.Satyanand vishwakarma Department of Electrical Engineering Chandigarh university Punjab, India (E-mail: satya0217@gmail.com)

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production scheme. The PV foundations are associated to a high voltage bus all one over a devoted dc/dc converter[7]. Consequently, K. L. Lian et al (2014) labeled a novel MPPT technique which could be applied to path the GMP at what time a PV panel is partly in the shade by vapors, snowflake, plants, and/or constructions. The presented method fundamentally associates PSO and P&O to build a hybrid technique [12].After that, Hong Li et al (2018) recommended an OD-PSO MPPT process to trace the Global MPP in PSCs. This process could speedily discover the minor area which comprises the GMPP deprived of comprehensive material regarding the PV array and consequently have a wild MPPT speediness [16]. And Thanikanti Sudhakar Babu et al (2018) proposed a PSO constructed array reconfiguration arrangement intended for the organization of PV units in a PV array that reveals improved array power production in partly shaded situations [17].

A. Recent works on hybrid PSOGSA

Mirjajili et al [18] has first presented the hybrid PSOGSA system. The procedure concatenates GSA and PSO through substituting the native exploration arrangement in PSO by the native exploration founded speeding up of GSA that consider mutually the local worst and best throughout each iteration during the velocity bring up-to-date stage. Consequently, they integrate the manipulation potential of PSO through the examination potential of GSA, and the suggested PSOGSA overtakes greatest target optimization tasks associated to the normal PSO and GSA. The concern in additional discovering and put on the PSOGSA increased consideration merely in these earlier years. The procedure planned in [18] has been implemented straight to solve optimum reactive power communication problematic in [19] and providing improved power loss likened to the conventional GSA and multi-objective development procedure. It has also been effectively functional to discover the optimum constraints in fuzzy controller tuning [20][21] and identifying the finest assignment and size of distributed generation elements which fulfills numerous purposes [22]. Numerous additional mechanisms have resorted for presenting their individual hybrid form of PSO-GSA to explain the optimization problematic. Contrasting [18], the effort [23] preserves confined search system of PSO and familiarizes GSA centered acceleration as an added component throughout the velocity inform. This novel form of procedure is applied to resolve a double impartial problematic to create optimum collision permitted trajectory for mobile robots and delivers quicker junction likened to inheritance GSA and PSO. The effort in [24] implemented unique velocity inform recommended through [18], though comprised a fuzzy logic measured all-out velocity restraint to evade deviation in the PSOGSA technique. Favorable outcomes were found after the process was implemented to resolve financial communication difficulties with valve point influence.

III. PROPOSED WORK

- *Algorithm description*

The computing rate is very expensive for the optimization of weight factor by classical optimization methods for instance exhaustive search & isn't real-world for this problematic. Consequently, this paper relies on metaheuristic time saving methods that search for near optimum keys at a rational calculation expenses. For all iteration i, N groups of means are produced, by which a representative relates to the grouping of weight vectors.

A) Conventional PSO

Particle swarm optimization is a standard advancement procedure owing from its basic methodology. Every representative is measured as subdivision of the technique. The particle for iteration i would have a velocity vi & position xi. The preeminent location attained through the elements in repetition i is demarcated, xi pbest and the best xi pbest amongst entire iterations is measured as the worldwide best location, xgbest . Each particle would attain an improved location by informing its present velocity and position conferring to the preceding location & earlier best locations of the particles [25]. The design of bring up to date the position and velocity of an n^{th} particle at i^{th} iteration is [26]:

$$v_n^{i+1} = [\mathrm{w} \times v_n^i] + [\mathrm{c}_1 \times rand() \times (\mathrm{x}_{Pbest}^i - x_n^i)] + [c_2 \times rand() \times (\mathrm{x}_{gbest} - x_n^i)] \quad (1)$$

$$x_n^i + 1 = x_n^i + v_n^i + 1 \quad (2)$$

where c1 is the cognitive factor, ω is weight of inertia index, c2 is factor of social, and rand() is an arbitrary value in the [0,1] series. The proportion of c1:c2 would define the significance assumed to global excellent and local excellent. The weight, ω, controls impression of preceding speed on the novel speed throughout upgrades, and mustn't be disorganized with weight of the founding beam (w), i.e, representative in advancement issue. The weight, ω, controls impression of going before speed on the novel speed all through updating, and mustn't be disarranged with weight of shaft establishing coefficient, w, i.e, agent in advancement issue.

B) Conventional Gravitational search algorithm

The GSA is a kind of swarm algorithm which is centered on the gravitational law [27]. Contrasting Particle swarm enhancement, the Gravitational search algorithm technique studies the worth of the results and the suitable values after informing the locations of the representatives. It delivers an advantage to the Gravitational search algorithm to seek for the best result sooner. The preceding overall excellent positions do not provide the velocity in the GSA. In contrast, the recent worst and best fitness reaction and the distinct energy of further elements performing on a representative would regulate the velocity of current. In GSA, an aggregate of N representatives, each particle is

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allocated with starting inertial mass, M. Entire power which performs the nth operator throughout the i-th cycle is:

$$F_n^i = \sum_{n=1, j\neq n}^{K} rand() \times G^i \frac{\overbrace{M_n^i \times M_j^i}^{F_{nj}^i}}{R_{nj} + \varepsilon} \quad (3)$$

Where Rnj is Euclidean separation among the nth & the jth molecule , Fnj is the power performing on the n-th specialist by the j-th operator where n, j ∈[1, 2,. . . N]. and ε is a minor constant. The gravitational constant G losses exponentially by i. where Gi =G0e(−꜀ i/I) , where G0 and α are the GSA regulatory coefficients though I is the user-defined thorough going cycles of the procedure . The operator acceleration by Newton's Second law is given by:

$$a_n^i = \frac{F_n^i}{M_n} \quad (4)$$

The mass of inertia of each specialist is in like manner rebuilt for the following cycle:

$$M_n^{i+1} = \frac{m_n^i}{\sum_{j=1}^{N} m_j^i} \quad (5)$$

Where by min is gravitational mass of the n-th agent as:

$$m_n^i = \frac{f_n^i - p_{worst}^i}{p_{best}^i - p_{worst}^i} \quad (6)$$

where f i n signifies the fitness rate at the nth particle throughout the ith repetition, and pi worst and pi best are the worst and best value in f i , correspondingly. By attained value for acceleration, the agent n velocity is simplified to:

$$v_n^{i+1} = rand() \times v_n^i + a_n^i \quad (7)$$

The original place of the n-th operator is lastly refreshed by (9).

C) Implementation of hybrid PSO-GSA algorithm

The integrated work of PSO-GSA in [18] is classified by way of small stage cooperation hybrid process for every classification in Talbi, which is measured by way of a small stage hybrid such as it concatenates the working of two current systems. The procedure is also collaboration built meanwhile the procedure is united as single and goes in similar. Though the particle bring up-to-date for GSA and PSO is alike, as revealed in eq (1), the revised velocity for mutually the algorithms vary, so an algorithm of PSO-GSA in [18] substitutes the unique PSO local exploration with the GSA's acceleration, that is fundamentally an excellent and bad conscious investigate task. Thus, the suggested process is:

$$v_n^{i+1} = [\omega \times v_n^i] + [c_1 \times rand() \times a_n^i] + [c_2 \times rand() \times (\chi_{gbest} - x_n^i)] \quad (8)$$

The cognitive factor, c1, is yet reserved in the procedure. It is realized that there are three main consistent factors in system: the cognitive parameter (c1), the inertia weight (ω), and c2 as the parameter of social. The 3 parameters manage the effectiveness of the process, speed and convergence problem. The integration of GSA & PSO in [23] is also characterized as collaboration of low-level integrated process for the similar causes. The planned MPPT technique is to keep the PSO's native local search and moreover adds acceleration of GSA to the velocity bring up to date. Hence, the proposed system is:

$$v_n^{i+1} = [\omega \times v_n^i] + [c_1 \times rand() \times (x_{Pbest}^i - x_n^i)] + [c_2 \times rand() \times (x_{gbest} - x_n^i)] + [c_3 \times rand() \times a_n^i]. \quad (9)$$

On top of c1, ω and c2, a new constant factor, c3 is presented in the form of PSO-GSA to regulate the finding of increasing speed.

To optimize the best duty cycle, three duty-cycles are fed to PSOGSA algorithm which is initialized randomly. After first iteration of PSOGSA algorithm, an optimum duty cycle is evaluated by PSO GSA based MPPT controller and fed to the buck-booster circuit to extract maximum power. For coming iterations, previous duty cycle is used as reference and two more duty cycle with reduction and increase by a fixed threshold is generated with respective to the PV array power by the ratio R1 and these three are fed to PSO GSA algorithm.

The variation in power of PV array and duty-cycle (D) are evaluated as under

$$D_{new} = D_{previous} \times \text{R}1 \quad (10)$$

where $D_{previous}$ is the previous optimized duty-cycle and R1 is evaluated by following equation

$$Ratio(R1) = \frac{Power(\text{D}^k)}{Power(\text{D}^{k+1})} \quad (11)$$

To optimize new duty-cycle value was given in eq (10) D1, D3 are initialized by change in +ve and -ve direction with a factor-value of threshold i.e.,

$$D_{i,new}^k = [\text{D}1 - thresh, \text{D}2, \text{D}3 + thresh] \quad (12)$$

Threshold value is selected in such a way that there are

least changes in the photovoltaic system's output power. This makes the algorithm of PSOGSA to exploit a wide extent to get the optimum global best value of duty cycle.
For decision making of optimum value depends upon ratio R1 the objective-function is used such that

$$Power(D_i^k) > Power(D_i^{k-1}) \quad (13)$$

From eq (13) it has been concluded that newly generated duty-cycle values can vary only with accordance to the operative power and will always stays near to the Gbest duty-cycle.

From (13), as per operating power fluctuation, the duty cycle will be varied hence its value will be near to the new optimum duty cycle. This makes the PSOGSA algorithm to find the optimum duty-cycle consistently in little number of iterations

IV. RESULTS AND DISCUSSIONS

The implementation of the suggested algorithm has been carried out in SIMULINK MATLAB. One diode model of photovoltaic cell is used to design the i-generation PVS array. Then buck-booster DC to DC converter, in which its control is done by MPPT block to get highest operating power from the PV array. The resistance R1 value is set at 1 ohm, inductance L set at .01 H, Capacitance C and C1 are set at 2e-3 F. IGBT switch is used for on and off of the buck-booster circuit for absorbing and releasing the power to load area. The designed model is given in figure below.

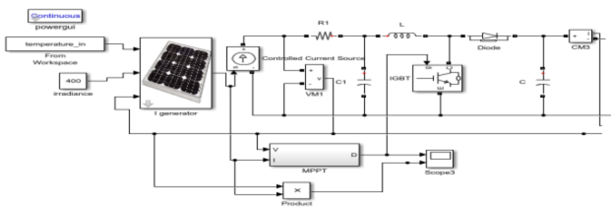

Fig 1: Single Diode based Simulink Model designed for PSOGSA based MPPT evaluation

The results for power, current and voltage outputs are noted down using PSO and PSOGSA based duty-cycle optimization by considering the similar parameters of the designed PV model. The outputs are compared in terms of line graph in fig 2-4

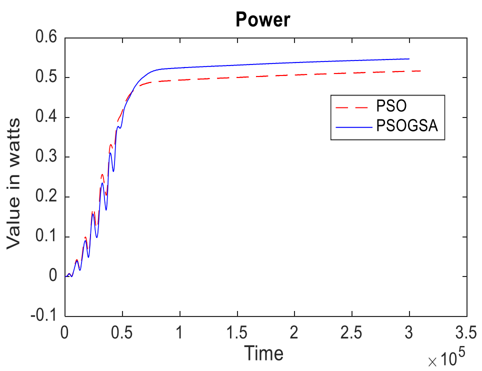

Fig 2: Comparison of Power waveform

As shown in fig 2, PSO and PSOGSA both have similar characteristic's in the starting point and attains constant output power at approx. 0.6 seconds of time but PSOGSA shows high value of maximum power but with very minute difference of about .01 watt

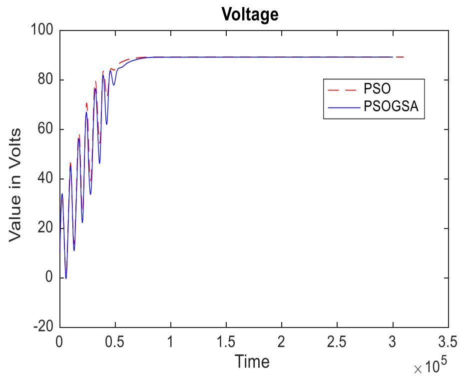

Fig 3: Comparison of Voltage waveform

Voltage waveforms are almost similar in PSOGSA and PSO algorithm but it has fluctuations in the start but when it achieves the MPP, fluctuations comes almost to zero value

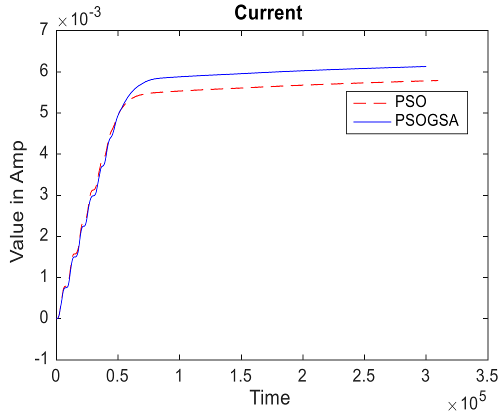

Fig 4: Comparison of current waveform

PSOGSA extracts more current from the system as compared to PSO algorithm which results in more power at the output.

As seen in the experimental results, PSOGSA algorithm is better in power extraction. In terms of stability and reliability of the MPPT control, both algorithms provide better results as there are no harmonics or fluctuations in current, voltage and power waveforms.

V. CONCLUSION

In this work, a hybrid algorithm was implemented through which particles can be initialized proficiently around the maximum power point to stay away from both needless and pointless circumstance in which the region being effectively looked by the swarm turns out to be excessively small. The experimental results show fast response of swarm based algorithms however PSOGSA

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gives effective results in the values of duty-cycle which results in higher power value. In PSOGSA based MPPT controller, particles migrates to the optimum position and there is reduction in waste time which causes higher speed of tracking of MPP. This is a good improvement than traditional PSO method as least number of iterations are required to reach optimum point.

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