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CONVENTIONAL AND ARTIFICIAL INTELLIGENCE BASED MAXIMUM POWER POINT TRACKING ALGORITHMSFOR SOLAR PV INTEGRATION – A COMPARATIVE STUDY

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Abstract—**Today's world is focussing on green and clean energy which necessitates the use of photovoltaic (PV) energy. Depletion of fossil fuels and emission of carbon is an important factor why the world is moving towards photovoltaic energy. However, the great challenge in implementing the photovoltaic systems lies in the high initial cost and low conversion efficiency. Therefore, a power converter with the ability to track the maximum power from the PV panels is essentially needed to increase the efficiency. Various Maximum Power Point Tracking (MPPT) techniques available for PV systems is presented. Characteristics of PV cells are explained. Conventional techniques like Perturb & Observe method, incremental conductance algorithm, fractional open circuit voltage and short circuit current methods were explained. Under the rapidly varying environmental conditions, the conventional techniques have not shown greater efficiency and therefore MPPT technique based on fuzzy logic, neural network, differential evolution (DE) algorithm and genetic algorithm (GA) were discussed. This paper compares and analyses the conventional and intelligent control based MPPT techniques with respect to tracking capability, methods of complex design, cost, ability to sense the change in environment, speed of convergence and conversion efficiency.**

Index Terms—**fuzzy logic, neural network, MPPT controller, photovoltaic.**

I. INTRODUCTION

Among many available renewable energy sources such as solar energy, wind energy, biomass energy, fuel energy etc., solar energy is one of the most convenient and popular form of renewable energy. Major advantage of solar energy is that it is maintenance free and environmental friendly. Major drawback is the high installation cost of the system. Photovoltaic systems contains solar cells interconnected, control and protection circuits and storage components. Because of variable irradiation throughout the day, the solar cell will not produce a constant and maximum power throughout the day. For extracting the maximum power from the photovoltaic array, a maximum power point tracker (MPPT) is designed for controlling the power electronic interfaces, which are used as an interface between solar array and load.

Since the photovoltaic cell (PV cell) has non-linear I-V characteristics, the output power of the cell entirely depends on the intersection point of load line with the I-V characteristics. One point is existing where maximum power is produced for particular solar radiation and cell temperature. MPPT determines this point for feeding maximum power to the load. Various MPPT algorithms have been developed and been implemented. But the selection of suitable algorithm for anapplication depends on the various factors such as the system cost, efficiency, implementation and complexity. MPPT controller will either control the duty ratio of the DC-DC converter or firing angle of the inverter. Depending on the methods for implementation they are classified as conventional methods and intelligent control methods. Fig. 1 shows the block diagram of the general photovoltaic system with MPPT controller.

II. PHOTOVOLTAIC CELL MODEL

Photovoltaic means the generation of electricity from light, here the light source is sun. Solar modules are connected in different combinations which forms the solar array, and a number of solar cells are used to form a solar module. Solar cells are manufactured from semiconductor layers made from silicon crystal [1]. The literature reveals that PV cells are represented by many models have been suggested for PV

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equivalent circuit.The most commonly used circuit modelcontains a single diode,the resistances connected in series and shunt [2]-[4]. As given in Fig.2, production of the amount of electrical energy is denoted by the current I_{ph}, which is in direct proportion to the solar irradiation. Internal resistance is represented by the seriesresistor and the leakage current is represented by the shunt resistance. Mathematical equation to represent the PV cell is written as follows:

$$I_{pv} = I_{ph} - I_D - \frac{V_D}{R_{sh}} \quad (1)$$

The diode characteristics is given by

$$I_D = I_0(e^{V_D/V_T A} - 1) \quad (2)$$

The voltage of a diode is given by

$$V_D = V_{PV} + I_{PV}R_S \quad (3)$$

Photovoltaic current Iph is expressed by

$$I_{ph} = (I_{SC} + K_1(T - T_{ref}))\lambda (4)$$

Here I_0 is the cell saturation of dark current, VT – thermal voltage of PV modules and is equal to kT/q, q is electron charge and is equal to 1.6 x 10^{-19} C, k is the Boltzman constant and is equal to 1.38 x 10^{-23} J/K, T is the p-n junction temperature in Kelvin, A is the diode ideality factor depends on the manufacturing technology, I_{SC} is short-circuit current of the cell at normal test condition of 1000 W/m^2 and 25^{0}C, K_1 is the coefficient of the short-circuit current of the cell, T_{Ref} is the reference cell temperature, λ represents the solar irradiance in W/m^2.Fig. 2 shows the equivalent circuit of photovoltaic cell.

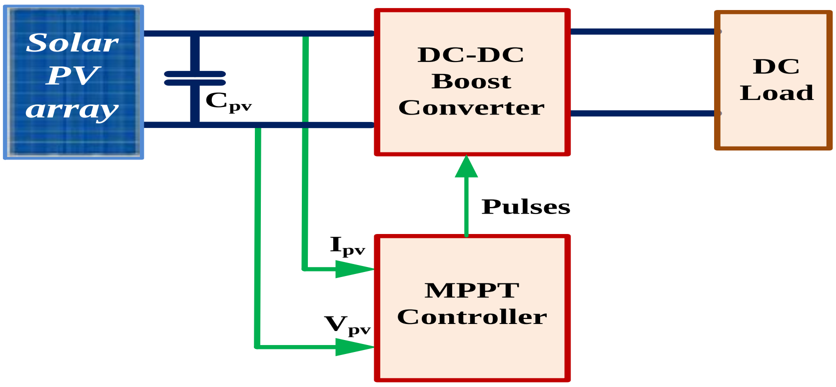

Fig. 1. Block diagram of PV system integration with DC load using MPPT

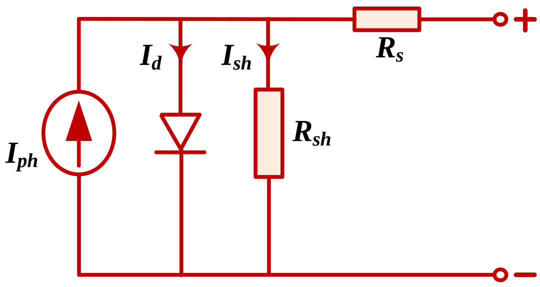

Fig. 2. Equivalent circuit of PV cell

III. PHOTOVOLTAIC CHARACTERISTICS

Photovoltaics have non-linear characteristics and the change of temperature and solar irradiance directly affects their performance and output power. Figs. 3 and 4 show the P–V and I–V characteristics of a PV array. The above characteristics show that the PV array exhibits non-linear output, which are directed by the irradiations from the sun. Under the full illumination condition of the sun, the P–V characteristic will have only a single peak. But multiple peaks will be appearing in the PV characteristics during the partial shading conditions.

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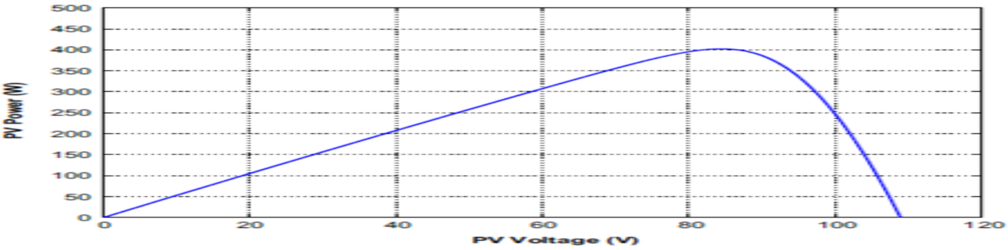

Fig. 3. P-V Characteristics of a typical PV array

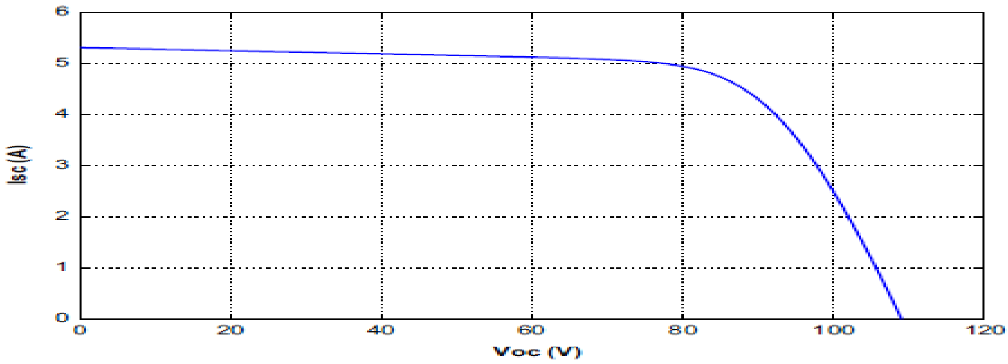

Fig. 4. I-V Characteristics of a typical PV array

IV. MAXIMUM POWER POINT TRACKING

The maximum power point is determined mainly by atmospheric temperature and solar irradiance. Because of the clouds or shadows of the object the maximum power point will be fluctuating. Maximum power point algorithm is an algorithm which is used to fix the dynamic operating point of the solar panel at the maximum power point by continuously computing the operating point of the solar panel [5]. For obtaining the maximum available power, accurate tracking of the operating point is must under all varying atmospheric conditions by using MPPT algorithm. The MPPT increases the power delivered by the solar panel to the load and the life span of the PV system also increased [6]. In the MPPT system, by adjusting the duty ratio of PWM based dc-dc converter the maximum power point is obtained. The significant condition while choosing a MPPT algorithm is the capacity of the algorithm to trace the true MPP among the local peaks taking into consideration of cost and speed of convergence. The various MPPT algorithms considered in this paper for review are shown in Table1. MPPT algorithms are organized undermajor groups in this paper. Onegroup discusses about the conventional MPPT algorithms. These algorithms shows satisfactory workingunder uniformirradiance.Anothergroup explains the use of intelligent techniques in MPPT algorithms. These exhibits satisfactory operationin both constant irradiance and partial shading conditions.

TABLE I
LIST OF MPPT METHODS

Conventional Methods	**Intelligent Methods**
Perturbation and Observation Method	Fuzzy Logic Approach
Incremental Conductance	Neural Network Approach
Fractional Open Circuit Voltage and Fractional Short Circuit Method	Differential Evolution Algorithm Approach
Ripple Correlation Control	Genetic Algorithm Approach

V. MPPT ALGORITHMS

A. Traditional MPPT Techniques:

1. Perturbation & Observation (P&O) Algorithm:

Because of the simplicity of practical implementation of P&O algorithm, this is most widely used algorithm. Primarily, the value of the voltage and current of PV array are sensed and the power is obtained. In this P&O method, the PV output voltage is changed by a small increment and therefore change of power (ΔP) occurs. If the change in power ΔP is positive, then the operating voltage will be moving toward MPP. The size of perturbation (C) also will be in the same direction. If ΔP is negative, then the operating voltage will be moving away from optimal point and therefore the size of perturbation also will be reduced in order to take the operating point back to MPP [7]-[12]. The P&O MPPT algorithm is depicted in Fig. 5. From the flowchart, the working point is moving towards the MPP when the PV power increases along with the operating voltage. This means the perturbation size is positive or remains unchanged. The working point is moving away from the MPP, when instantaneous power reduces while the operating voltage also reduces. Therefore, the perturbation size is reversed to move the operating point to reach the true MPP. Table 2 summarizes the perturbation direction in P&O algorithm. The drawback of this algorithm is that under fast changing atmospheric conditions, the tracking efficiency reduces. The operating point continuously oscillates around MPP and changes the direction of perturbation after measuring ΔP. Also under varying irradiance conditions, the P&O fails to track true MPP [13]. The simple structure and easy implementation, in stand-alone mode as well as grid-connected mode are the major advantages of P & O algorithm.

2. Incremental Conductance Algorithm

This method uses the slope (dP/dV) of power- voltage characteristic, the slope of P-V curve is zero atMPP, and is positive on left and negative on right [14]. This method eliminates the drawback of P&O method which is the oscillation of operating point under varying atmospheric conditions. dP/dV is called as the power gradient. These gradients are summarized as follows:

dP/dV = 0 at MPP
dP/dV> 0 left of MPP
dP/dV< 0 right of MPP

From the characteristics of the PV array (I-V and P-V),

$$\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V\frac{dI}{dV} \cong V\frac{\Delta I}{\Delta V} \quad (5)$$

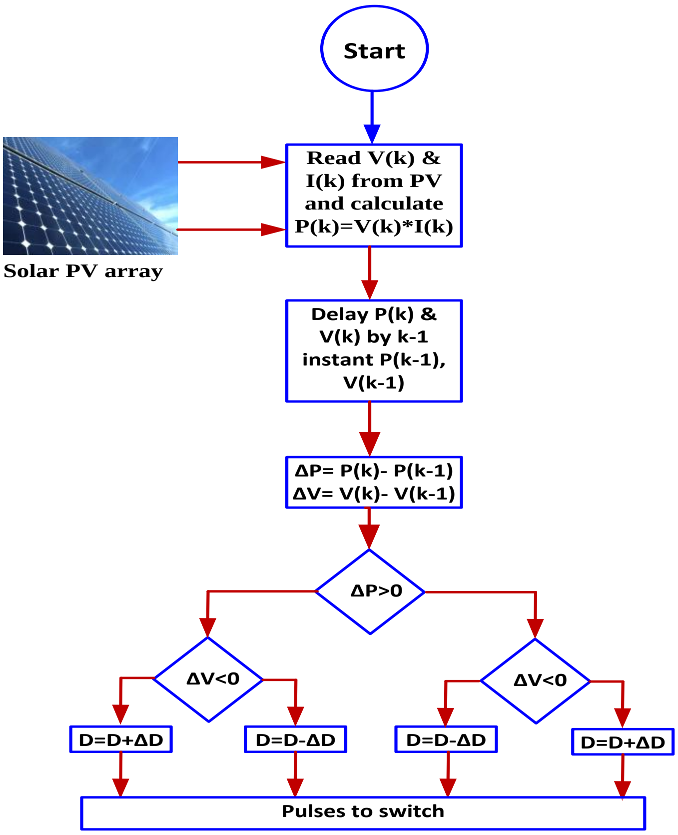

Fig. 5. Flowchart for Perturbation and Observation MPPT algorithm

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TABLE II
P& O ALGORITHM SUMMARY

Perturbation	Change in Power	Next Perturbation
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

Now the point of dP/dV can be written as

$\frac{\Delta I}{\Delta V} = -\frac{I}{V}$,at MPP. (6)
$\frac{\Delta I}{\Delta V} > -\frac{I}{V}$, at left of MPP. (7)
$\frac{\Delta I}{\Delta V} < -\frac{I}{V}$, at the right of MPP. (8)

In the Incremental Conductance algorithm, the cycle is started by obtaining present value of V and I at V(t) and I(t). The flow chart in Fig. 6 shows that the tracking of MPP done by comparinginstantaneous conductance (I/V) valueand incremental conductance (ΔI/ΔV) value. Reference voltage, V_{ref}, is either decreased or increased depending on the above comparison. If V_{ref} is equal to V_{MPP}, the MPP is reached. This point is the stopping point of the algorithm, the corresponding values will be stored. If any environmental changes then there will be a change in ΔI and at such conditions the algorithm will be recalculated until optimum point is obtained [15]. The speed of MPPT algorithm is determined by the incremental size. If the incremental size is large, then the time taken for tracking is reduced; but, the system oscillates about this point of MPP [16]. This INC algorithmwill perform better under quicklychanging atmospheric conditions and also oscillations are less. However, the efficiency of the algorithm is somewhat closer to the P&O method. Major drawback identified isthat under varying irradiance and alsopartial shading conditions, the global MPP is not tracked. At last, because of the complexity of control circuits needed for implementing the INC algorithm system cost is high.

3. Fractional Open Circuit Voltage Algorithm
For offline applications, the open-circuit voltage MPPT is used which is a simplified technique [16]. This method is based on the fact that there is an approximately linear relation between the open circuit voltage and voltage at maximum power point (V_{MPP}) under changing atmospheric conditions. This can be given by

$V_{MPP} \approx K\ V_{OC}$ (9)

where K varies between 0.7 and 0.8 which depends on the PV cell characteristics.
V_{OC} is obtained by opening the load and the V_{MPP} is approximated using the above formula. This method will not provide accurate operation of PV array at MPP and is only an approximation. This is the main drawback of this method.

4.Fractional Short Circuit Current Algorithm
This MPPT method is also an offline method. There is an approximate linear relation between the short-circuit current I_{SC}, and current at maximum power point I_{MPP} [16]. This can be given by

$I_{MPP} \approx K\ I_{SC}$ (10)

where K is a constant and it lies in the range of 0.8 to 0.9
The short circuit current is determined by shedding the load connected to the PV array. After that, I_{MPP} is calculated using the above formula. This method is comparatively accurate when compared with fractional voltage method. But this fractional current method needs higher cost for implementation.

5. Ripple Correlation Control Algorithm
When the PV array is connected to a DC-DC converter, the voltage and current ripples are created because of the converter switching action. Therefore, there will be ripples present in the power produced from PV array which will affect the PV systemperformance. In [17] - [20], it is reported that MPPT can be done using ripple correlation control. The MPP will be reached when the power gradient becomes zero. To achieve this condition, the RCC correlates between dP/dV and I or voltage both varies with time.
The working point is less than MPP. Contrast to this, when the V or I decreases and decreases, operating point is greater than MPP. Combining these operations, PI or PV are positive on left, zero at MPP and negative on right of MPP.

$d(t) = -K_3 \int \dot{P}\dot{V} dt$ (11)
$d(t) = -K_3 \int \dot{P}\dot{I} dt$ (12)

This ripple correlation control method is not considering the parameters such as PV array voltage and current. It takes only the duty-ratio of the power converter for tracking the maximum power. This method is simple and cost is less and high speed.The convergence time is decided by the converter switching frequency. When the solar irradiation is low, this technique is slow because of the requirement of large tracking steps near the true MPP.

B. Intelligent Control Based MPPT Techniques

1. Fuzzy Logic MPPT Controller

Application of intelligent controllers in implementing MPPT algorithms of PV systems showed best performances, quickresponses and also less oscillations in steady state for rapidly varying temperature and irradiance conditions [21].The fuzzy logic MPPT does not require the exact mathematical model of PV system [22]-[24]. Fuzzy logic controller is simpler comparing with other intelligent controllers. The researchers are showing more attention on fuzzy logic controller (FLC) for controlling converter, electrical drives and also process control applications because of its better response than other conventional controllers [25]-[27].The frequent and imprecise variation of the weather conditions shown by PV arrays can be accurately traced with FLC. To take the merits of this controller, MPPT algorithm is integrated with FLC. The two input variables in this FLC based MPPT are the error (e) and change in error (Ce).These variables at the kth sample time are

$$e(k) = \frac{dP}{dV}(k) - \frac{dP}{dV}(k-1) \quad (13)$$
$$C_e(k) = e(k) - e(k-1) \quad (14)$$

where e(k) – error of the position of operating point of load at the kth instant.
$C_e(k)$ – moving direction of this point.
Mamdani's fuzzy inference system is used and the centre of gravity method is used for defuzzification to calculate the output as shown in Fig.7.

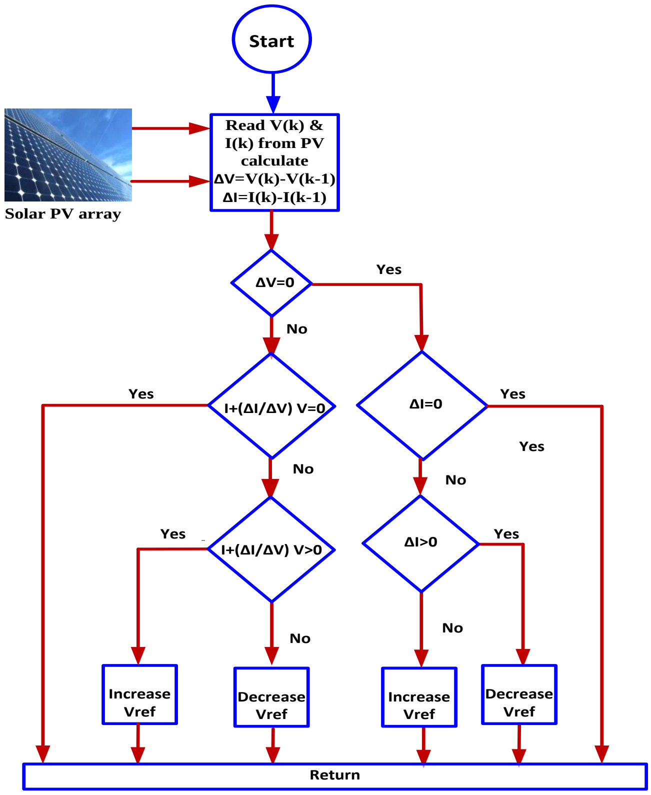

Fig. 6. Flowdiagram for Incremental conductance algorithm

2. Neural Network MPPT Controller:

The drawbacks of conventional controllers for MPPT are also overcome by the application of an ANN based MPPT Control technique. The use of ANN improves the system performance and system efficiency to a better rate than traditional methods. Neural network with the multilayer structure is employed [28] – [30]. Artificial neural network with offline training based MPPT is added to compute the temperature and irradiance from the PV array.Supervised learning is implemented to eliminate the error by providing the required multiplication factors to the weights at the hidden layer. This technique performs better under rapidly varying environmental conditions.Here the non-linearities of PV panel are overcome by supervised learning feed forward trained network. Flowchart for MPPT algorithm

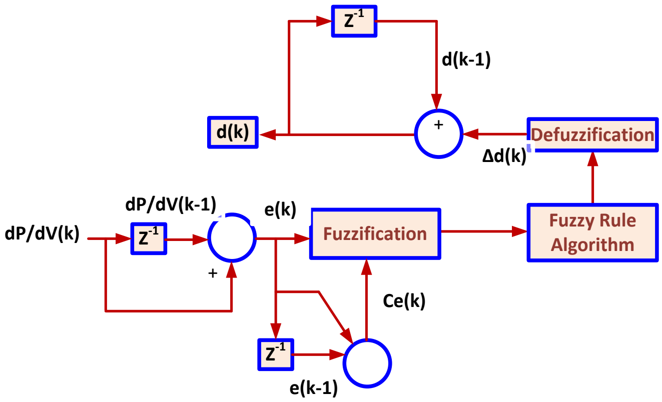

Fig. 7 Structure of Fuzzy Logic Controller

Based on artificial neural network is shown in the Figure 8. [31] – [32].

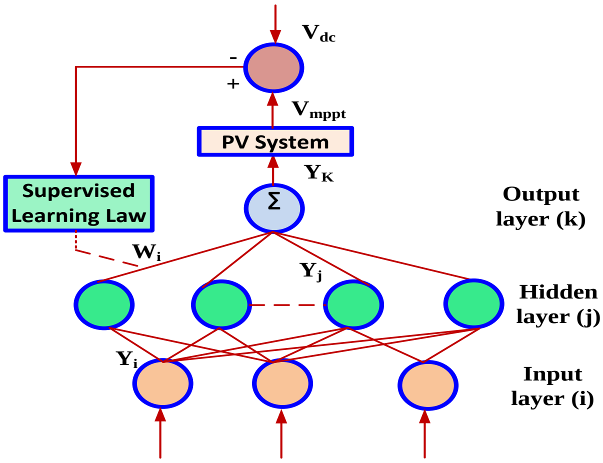

Fig. 8 ANN Based MPPT

Artificial neural network (ANN) finds applications in many areas because of the better performance on non-linear tasks.The three layers of ANN are input, hidden and output layers. In Fig. 9, the interconnection between i and j gives by wij. Inputs to the ANN are summed and modified by weights. The structure of artificial neural network consists of a system to receive an input, data processing, and an output. Input variables are temperature, solar irradiation and short-circuit current or open-circuit voltage. The system accuracy is decided by the hidden layers and also the process of training. In partially shaded condition, ANN predicts the global MPP voltage and power. The difference between the actual and reference voltage is given as an error for the MPPT controller. TheANN has twotopologies as feed-forwardand the recurrent topology.The feed-forward network contains no feedback connections. There current network k has feedback connections with short term memory. For better results under partial shaded conditions, ANN combined with fuzzy logic can be used. The optimum PV voltage can be found out by training three layers of feed-forward ANN. Comparing with P&O, this method shows twice the tracking efficiency.

3. Differential Evolution Algorithm (DE)

In [33] differential evolution algorithm is discussed for global optimization. The practical problems like non-differentiable, discontinuous, nonlinear, noisy, flat, multidimensional or systems having more number of local minima, constraints or stochasticity can make use of this DE algorithm.

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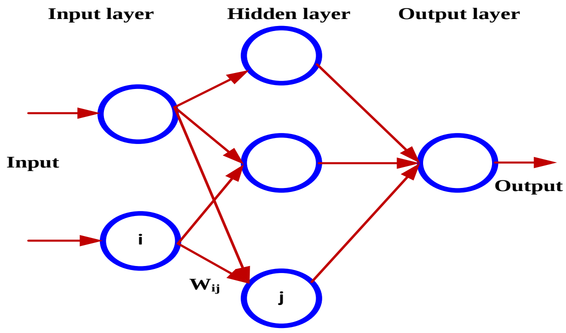

Fig. 9 ANN Layers

Only few parameters are required in this algorithm, hence this method can be easily implemented. Basic requirements of this algorithm are particles population and the number of iterations needed to generate an optimal solution is lesser.
In DE, two-dimensional target vectors are utilized initially with x_i as the population for each iteration and G given in (15). In each iteration, the total number of particles is maintained at uniform value.

$$X_{i,G}\ ,\ i = 1,2,\ldots\ldots,N_P \quad (15)$$

$$V_{i,G} = x_{r1,G} + F*(x_{r2,G} - x_{r3,G}) \quad (16)$$

where F is in the range of 0 to 1.

The mutation process aims at generating the donor vectors with NP particles.Afterwards, the donor vectors are combined with the target vectors through crossover process and the trial vectors, $u_i$are generated. Equation (17) shows the condition for crossover. A comparison is made between the random number in the range [0,1] and the crossover rate CR in the range [0,1]. Consider the

$$u_i = \begin{cases} v_i; if rand \geq CR \\ x_i; else \end{cases} \quad (17)$$

Next to the crossover process, the following process is done:

$$x_{i+1} = \begin{cases} u_i; iff(u_i) \geq f(x_i) \\ x_i; else \end{cases} \quad (18)$$

Figure 9 gives the flowchart for DE algorithm.

MPPT based on DE Algorithm:
Multiple peaks will be there in the P-V characteristics during partial shadedconditions and therefore the global MPP is not tracked by the traditional P&O algorithm, all the times.The DE algorithm is best suited to track the GMPP under partial shaded conditions [34] – [36]. To ensure the operation of PV system at the GMPP, the duty ratio of the DC-DC converter is adjusted. Therefore, the target vector D_i is the duty ratio of the converter. Initially, duty cycle is initialized as shown in flowchart in Figure 10. Only three particles are used to reduce time consumption. Equation (15) becomes (19) in the proposed MPPT algorithm as follows:

$$D_{i,G};\quad i = 1, 2, 3 \quad (19)$$

After the initialization, PV array powers $P_i$are estimated for the three duty cycles. Then, the highest power in P_i is chosen as P_{best}, then D_i is kept as $D_{best.}$ If the variation among the three power values ΔP_i is more than 1.5%, the process continues to make the donor vector DV_i through equation (20), where F is 0.6.

$$DV_{i,G} = \begin{cases} D_{r1,G} - F*\left|D_{r2,G} - D_{r1,G}\right|; if D_{r1,G} \geq D_{best} \\ D_{r1,G} + F*\left|D_{r2,G} - D_{r1,G}\right|; else \end{cases} \quad (20)$$

Donor vectors and target vectors crossover with each other as in equation (21), where CR is 0.67.

$$DU_i = \begin{cases} DV_i; if rand \geq CR \\ Di; else \end{cases} \quad (21)$$

After obtaining all the values of $DU_{i,}$ the comparison is made with P_i. Then the duty cycle corresponding to the higher value of power is taken as the next target vector using equation (22):

$$D_{i+1} = \begin{cases} DU_i; if PUi \geq Pi \\ Di; else \end{cases} \quad (22)$$

Then, the algorithm repeats from block 2 in the flowchart until ΔP_ibecomes lower than 1.5%. Consequently, D_{best} is the duty cycle of the converter and ΔP_i is noted. If ΔP_i is more than 1.5%, then the algorithm repeats again from block 1; otherwise, it continuestrackingΔP_i.

4. Genetic Algorithm Based MPPT Algorithm
The benefits of the optimization algorithm based on genetic algorithm [37] are given below:

i. In GA, codes of system parameters are used for system modelling.
ii. For optimization procedure of the system, work is on the population of points instead of a single point.
iii. MPPT can be done by function values and there is no need for calculation of any other value existing in the system.
Genetic algorithm (GA) based MPPT controller suitable for partial shading conditions has been introduced in [38]-[39]. GA principle and the DE algorithm are almost similar. In GA the tracking depends on genetic behaviour. The selection, crossover and mutation are the basic operators in GA. Selected individual is taken as a solution for optimization in a random population,. Fig.11 shows a simplified GA technique for finding optimization. GA parameters are identified based on the procedure in Fig. 10. They are in binary form or real code form. Every chromosome has individual parameters and hence several solutions.
The performance index is found by the objective function based on the convergence value and error. After this, the random generation of initial population is made using random set of chromosomes. Population size depends on optimization problems chosen. For larger population size the solutions are converged faster with few generations itself. But this needs more time for computation.When the convergence value is reached, the process comes to an end. The process continues by applying genetic parameters for the next generation and will continue till it reaches the optimum point. It should be ensured that the algorithm is tracking the global maximum. In Ref. [40], this GA method applied for MPPT based on the fuzzy logic approach under varying irradiance and temperature conditions.
The GA is applied to choose the FLC parameters like rule base, membership function and tuning is done to their optimum value with the fitness as highest. Therefore there is a considerable improvement in the FLC performance for the optimizing techniques.
MPPT controller based on enhanced bayesian method is discussed in [41] and based on voltage sensor based method is described in [42]. High speed MPPT tracking module is implemented in [43].

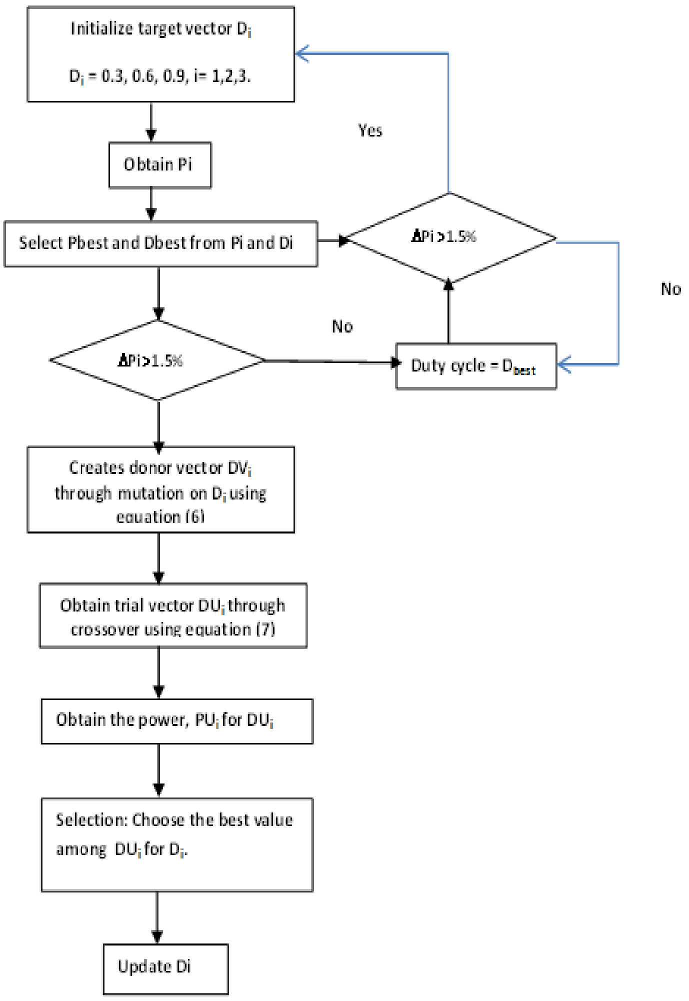

Fig. 10. Flowchart for differential evolution algorithm in MPPT control

VI. ANALYSIS

From literature reviews, many MPPT techniques are available ranging from traditional to advanced intelligent and optimization techniques. But all the techniques have the common objective of maximizing the output power from the PV under uniform irradiance and shading. The discussion of the various MPPT techniques is presented in this paper according to the factors namely, MPP tracking capability, methods of complex design, cost factor, ability to sense the change in environment, speed of convergence and conversion efficiency.

6.1 MPP Tracking Capability

Because of the unpredictable solar irradiance, there always occurs a partial shading tendency. Because of this condition, there is a formation of multiple peaks on the P–V characteristics, which will directly affect the efficiency of tracking of the system.

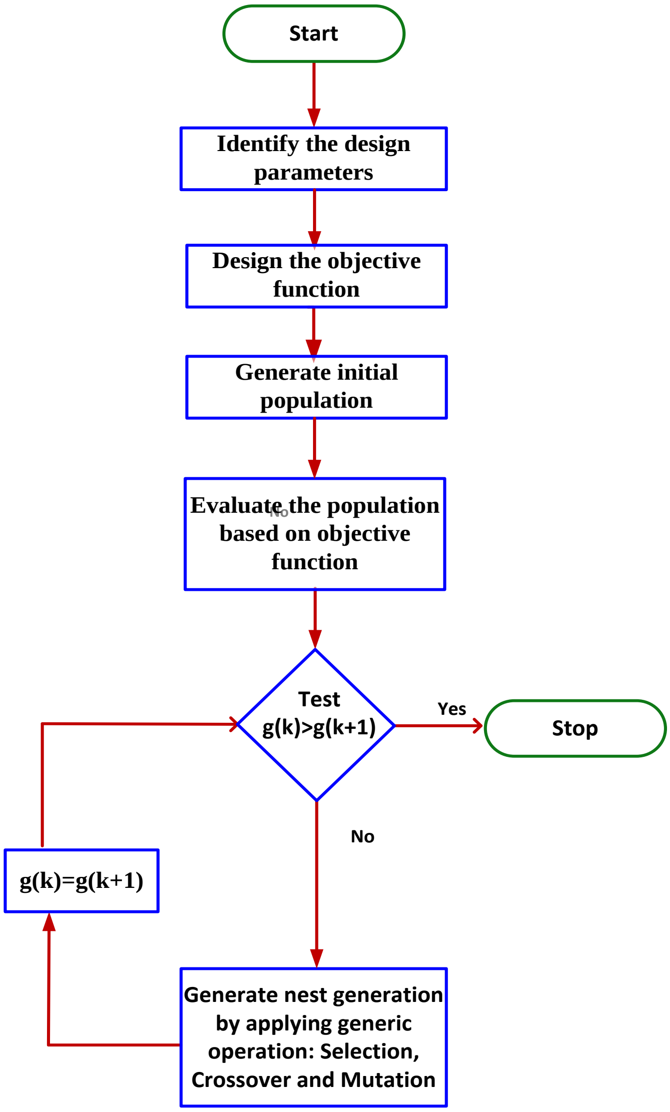

Fig. 11. Flow chart of MPPT algorithm based on GA

The true MPP are not exactly tracked by the MPPT algorithms which are traditional and therefore they are not suitable for true MPP tracking instead intelligent and optimization based MPPT algorithms are most suited for tracking the global maximum.Therefore the GA and the DE algorithms have the superior tracking capacity. ANN and FLC methods needs a separate driver circuit for the MPPT controller.

6.2.Methods of complex Design

The factor of complexity in design plays a major role in choosing the most suitable MPPT for a particular application. The efficiency of tracking depends on the accuracy of algorithm which predicts the local peaks and attains the global peak. If not, the energy produced by the photovoltaic system will not be optimum. Human expertise in working with the analog circuits also plays a vital role in implementing MPPT. Most of the intelligent and optimization based MPPT algorithms are using only digital circuits. This needs a sound programming knowledge in software.

6.3. Cost factor

In many applications, especially while commercializing the new product, an economic factor to be considered as the most important. For MPPT, this cost depends on the number of sensors required for implementation of the system, the factor of complexity in the design and also the selection of analog system or digital system. Overall system cost is decided by the number of sensors and the type of sensors used. Because, current sensors are much costlier than voltage sensors. Implementation cost is also affected by the hardware types chosen for controlling the MPPT algorithm while the system capital cost is affected by the selection of algorithm applied. Also the analog circuits costs less compared with the digital circuits which requires the knowledge of programming in computer.

6.4. Responsiveness

The MPPT algorithm should be highly responsive for any changes in surrounding atmosphere. The MPPT algorithm must have quick response and trackingduring uniform solar irradiance and also shading condition. GA and DE algorithms will be update automatically for these changes in solar irradiation and temperature of atmosphere.

6.5. Convergence Speed

The convergence speed of the MPPT algorithm is decided by the sensitivity of the system. If the MPPT algorithm is highly sensitive then it should be able to converge at a very high speed to the desired operating voltage and current quickly, irrespective of changes inatmospheric conditions. Relatively, the traditional MPPT techniques require more time to attain the true MPP in comparisonwith the intelligent and optimization techniques. The intelligent and optimization techniques perform tracking with minimal or negligible oscillation. In a nutshell, while designing a PV system, the converging speed and the tracking performance are also the main factors.

VII. CONCLUSION

A review of MPPT methods and implementation methods have been presented. According to the method of tracking the maximum power from the photovoltaic array, the MPPT techniques were classified as conventional and intelligent control based techniques. The general photovoltaic cell model and its characteristics were discussed. The general explanation of each MPPT technique with its main advantages and disadvantages were presented. Each MPPT algorithm has a different control strategy. MPPT algorithms are classified according to MPP tracking capability, methods of complex design, cost factor, ability to sense the change in environment, speed of convergence and conversion efficiency. Literature review shows that the traditional MPPT algorithms will perform better under constant irradiance conditions. But under rapidly varying environmental conditions, the intelligent control based algorithms shows better results. In Perturb & Observe method and incremental conductance algorithm, the maximum power point will oscillate. This is the major drawback in conventional methods. The speed of tracking the maximum power is faster and the oscillations are reduced while using intelligent control based MPPT techniques. The ultimate focus of the various ongoing researches in MPPT algorithms is to achieve a simple, low cost and more efficient algorithm. Because of the non-linear characteristics of the photovoltaic cells, the need for MPPT controller is essential to harvest the maximum power from the cells. Therefore by making use of the proper MPPT technique for the photovoltaic systems, relying on fossil fuel sources can be minimized further in future by fully harvesting and utilizing PV power output.

VIII. REFERENCES

[1]. Rodrigues EMG, et al.,(2008). Simulation of a solar cell considering single diode equivalent circuit model, presented at the international conference on renewable energies and power.

[2]. Huan-Liang Tsai, Ci-Siang Tu and Yi-JieSu, (2008). Development of Generalized Photovoltaic Modeling Using MATLAB/Simulink, Proceedings of the World Congress on Engineering and Computer Science 2008 WCECS 2008, October 22-24, 2008, San Francisco, USA.

[3]. W. Xiao, F. F. Edwin, G. Spaguolo, and J. Jatskevich, (2013). Efficient Approaches for Modeling and Simulating Photovoltaic Power Systems, IEEE Journal of Photovoltaics, vol. 3, no. 1, pp. 500-508, Jan. 2013.

[4]. A. Ahmed and EL TAYYAN. (2013). A simple method to extract the parameters of the single-diode model of a PV,Turkish Journal of Physics, pp. 121-131, March 2013.

[5]. Houssamo I, Locment F, SechilariuM.,(2010). Maximum power tracking for photovoltaic power system: development and experimental comparison of two algorithms, Renewable Energy; 2010;35(10):2381-87.

[6]. M. A. Eltawil and Z. Zhao, (2013). MPPT techniques for photovoltaic applications. Renewable and Sustainable Energy Reviews, vol. 25, pp. 793–813.

[7]. JiradaGosumbonggot, (2016). Maximum Power Point Tracking Method using Perturb and Observe Algorithm for small scale DC voltage converter", Procedia Computer Science(Elsevier) 86, pp. 421 – 424.

[8]. M. Dris, B. Djilani, (2013). Comparative study of Algorithms (MPPT) applied to photovoltaic systems. International journal of renewable energy research, vol. 3, no. 4, 2013.

[9]. M. Calavial, J. M. Periel, J. F. Sanz and J. Sallan, (2010). Comparison of MPPT strategies for solar modules, in Proc. Int. Conf. Renewable Energies Power Quality, Granada, Spain, Mar. pp.22-25.

[10]. T. Esram and P. L. Chapman, (2007). Comparison of photovoltaic array maximum power point tracking techniques. IEEE Trans. Energy Conv., vol. 22, no. 2, pp. 439–449.

[11]. Alivarani Mohapatra, Byamakesh Nayak, Priti Das and Kanungo Barada Mohanty, (2017). A review on MPPT Techniques of PV system under partial shading conditions. Renewable and Sustainable Energy Reviews 80,pp.854 – 867.

[12]. Hohm DP, RoppME,(2003). Comparative study of maximum power point tracking algorithms, Prog Photovoltaics Res Appl 2003;11: pp.47–62.

[13]. Salas EOV, BarradoA, LazaroA, (2006). Review of the maximum power point tracking for standalone photovoltaic systems. IEEE Transactions on Energy Conversion 2006; 22: pp. 439–49.

[14]. KanteVisweswara, (2014). An Investigation Of Incremental Conductance Based Maximum Power Point Tracking For Photovoltaic System,Energy Procedia 54 (2014) pp.11 – 20.

[15]. F. Liu, S. Duan, F. Liu, B. Liu, and Y. Kang, (2008). A variable step size INC MPPT method for PV systems,IEEE Transactions on Industrial Electronics, vol. 55, no. 7, pp. 2622–2628.

[16]. K. K. Kumar, R. Bhaskar, and H. Koti, (2014). Implementation of MPPT algorithm for solar photovoltaic cell by comparing short-circuit method and incremental conductance method, Procedia Technology, vol. 12, pp. 705–715.

[17]. Esram T, et al., (2006). Dynamic maximum power point tracking of photovoltaic arrays using ripple correlation control,IEEE Transactions on Power Electronic; 21: pp.1281-91.

[18]. Casadei D, et al., (2006). Single-phase single stage photovoltaic generation system based on a ripple correlation control maximum power point tracking, IEEE Transactions on Energy Conversion; 21: pp. 562-8.

[19]. C. Barth and R. Pilawa-Podgurski, (2015). Dithering digital ripple correlation control for photovoltaic maximum power point tracking. IEEE Trans. Power Electron., vol. 30, no. 8, pp. 4548–4559.

[20]. P. Krein, (1999). Ripple correlation control, with some applications," in Proc. IEEE Int. Symp. Circuits and Systems, ISCAS '99., vol. 5, 1999, pp. 283–286.

[21]. S. A. Khan and M. I. Hossain, (2010). Design and Implementation of Microcontroller Based Fuzzy Logic Control for Maximum Power Point Tracking of a Photovoltaic System, in 6th International Conference on Electrical and Computer Engineering, Dhaka, Bangladesh, 2010.

[22]. F. Chekired, C. Larbes, D. Rekioua, and F. Haddad, (2011), Implementation of a MPPT fuzzy controller for photovoltaic systems on FPGA circuit, Energy Procedia 6, pp. 541–549.

[23]. C. K. Sundarabalan , K. Selvi , and K. S. Kubra , (2015). Performance investigation of fuzzy logic controlled MPPT for energy efficient solar PV systems, Power Electron. Renewable Energy Syst.326, pp. 761–770.

[24]. AhmadH.ElKhateb, Nasrudin Abd Rahim, Jeyraj Selvaraj, (2013). Fuzzy Logic Control approaches of a maximum power point employing SEPIC converter for standalone photovoltaic system,Procedia Environmental Sciences (Elsevier), 17, pp. 529-536.

[25]. C.-S. Chiu,(2010). T-S fuzzy maximum power point tracking control of solar power generation systems, IEEE Trans. Energy Conv., vol. 25, no. 4, pp. 1123–1132.

[26]. O. Guenounou, B. Dahhou, and F. Chabour,(2014). Adaptive fuzzy controller based MPPT for photovoltaic systems, Energy Conversion and Management, vol. 78, pp. 843–850.

[27]. B.N.Alajmi, K.H.Ahmed, S.J.Finney, and B.W.Williams, (2011). Fuzzy-Logic-Control Approach of a Modified Hill-Climbing Method for Maximum Power Point in Microgrid Standalone Photovoltaic System, IEEE Trans. Power Electronics, vol. 26 no. 4, pp. 1022-1030.

[28]. B. Pakkiraiah and G.D. Sukumar, (2016). A New Modified Artificial Neural Network Based MPPT Controller for the Improved Performance of an Asynchronous Motor Drive, Indian Journal of Science and Technology, Vol 9(45), DOI: 10.17485/ijst/2016/v9i45/105313.

[29]. Lina M. Elobaid, Ahmed K. Abdelsalam , Ezeldin E. Zakzouk, (2015). Artificial neural network-based photovoltaic maximum power point tracking techniques: a survey, IET Renewable Power Generation, 2015, Vol. 9, Iss. 8, pp. 1043–1063.

[30]. A. B. G. Bahgat, N. H. Helwa, G. E. Ahmad, and E. T. E. Shenawy, (2005). MPPT controller for PV

systems using neural networks, Renew. Energy, vol. 30, no. 8, pp. 1257–1268.

[31]. T. Hiyama and K. Kitabayashi, (1997). Neural network based estimation of maximum power generation from PV module using environment information, IEEE Trans. Energy Conv., vol. 12, no. 3, pp. 241–247.

[32]. S.Reza, S.Salwah, and B.Salim,(2014). Neurocomputing Real-time frequency-based noise-robust Automatic Speech Recognition using Multi-Nets Artificial Neural Networks: A multi-views multi-learners approach,Neurocomputing vol. 129, pp. 199-207.

[33]. R.Storn and K.Price,(1996). Minimizing the real functions of the ICEC'96 contest by differential evolution, in proceedings of the IEEE international Conference on Evolutionary Computation (ICEC'96), pp.842-844.

[34]. IshaqueK,etal.,(2010). A novel maximum power point tracking control of photo-voltaic system under partial and rapidly fluctuating shadow conditions using differential evolution, IEEE symposium on industrial electronics and applications.

[35]. Storn R, Price K, (1997). Differential evolution—a simple and efficient heuristic for global optimization over continuous spaces, Journal of Global Optimization. pp.341–59.

[36]. Das S, et al,(2008). Particle swarm optimization and differential evolution algorithms: technical analysis, applications and hybridization perspectives",Advances of computational intelligence in industrial systems, 116,(ed).

[37]. Ramaprabha R, and Mathur BL., (2012). Genetic algorithm based maximum power point tracking for partially shaded solar photovoltaic array", International Journal of Recent Research in Interdisciplinary Sciences, pp.161-163.

[38]. Stefan Daraban, DorinPetreus, Cristina Morel,(2014). A novel MPPT (maximum power point tracking) algorithm based on a modified genetic algorithm specialized on tracking the global maximum power point in photovoltaic systems affected by partial shading, Energy Elsevier ,Volume 74, pp.374-388.

[39]. Slimane Hadji, Jean-Paul Gaubert , Fateh Krim, (2014). Experimental analysis of genetic algorithms based MPPT for PV systems, Renewable and Sustainable Energy Conference (IRSEC).

[40]. MessaiA,etal, (2011). Maximum power point tracking using GA optimize fuzzy logic controller and its FPGA implementation, Solar Energy. pp.265–77.

[41]. F. Keyrouz, (2018). Enhanced Bayesian Based MPPT Controller for PV Systems, IEEE Power and Energy Technology Systems Journal, pp. 11-17.

[42]. M. Killi and S. Samanta,(2019). Voltage-Sensor-Based MPPT for Stand-Alone PV Systems Through Voltage Reference Control. IEEE Journal of Emerging and Selected Topics in Power Electronics, pp. 1399-1407.

[43]. S. Selvakumar, M. Madhusmita, C. Koodalsamy, S. P. Simon and Y. R. Sood, (2019). High-Speed Maximum Power Point Tracking Module for PV System, IEEE Transactions on Industrial Electronics, vol. 66, no. 2, pp. 1119-1129.

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