# Comprehensive Review on maximum power point tracking methods for SPV system

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**Abstract -** *Power generation from solar source is increasing exponentially due to requirement of green energy is increased. In view of the threat of scarcity of conventional resources like coal, gas and fossil fuels etc. In last few years many researchers worked on solar system to develop system that can extract as much as power from solar irradiations. MPPT is a technique that includes further methods of tracking power. In the research carried out it is observed more than 30 methods under different categories track maximum power from PV system.*

***Key Words*: maximum power point tracking (MPPT), solar photovoltaic system (SPV), perturb & observe (P&O), Fuzzy logic controller (FLC). Incremental Conductance (INC)**

## 1. INTRODUCTION

Solar energy is a renewable source of electrical energy. This source is rapidly increasing source to generate electricity these days as non-renewable sources are limited to use and not environment friendly. In the list of renewable sources wind and solar are on top. The research on solar is going on to increase efficiency as it have only 30-40% efficiency of output power. Many techniques and methods are implemented on solar system to make it stable and efficient. Photovoltaic (PV) is used to absorb solar energy from solar irradiations and convert it into electrical energy. That energy is transmitted through converters to increase or decrease the amplitude of voltage. The problem associated with solar irradiations is that it is variable by nature, so the generated power is also variable and need to be stable for transmission system. This energy is further stored in storage devices such as batteries. The very first method developed for extraction of maximum power is based on mechanical structure in which the PV panel rotates as per direction of solar beam or solar tracking. Then another method is developed on the basis on parameter tracking at particular time. This method is known as "Maximum Power Point Tracking (MPPT). In this method, the operating point is moved according to peak point of PV voltage or Current, so that the maximum power can be tracked. The MPPT computing system measures the input and/or output voltage and current as well as the climatological variations then computes the power to control the converter input impedance by changing the duty-cycle of the control signal. The basic structure of location as well as connections of MPPT is presented in fig.1[3]

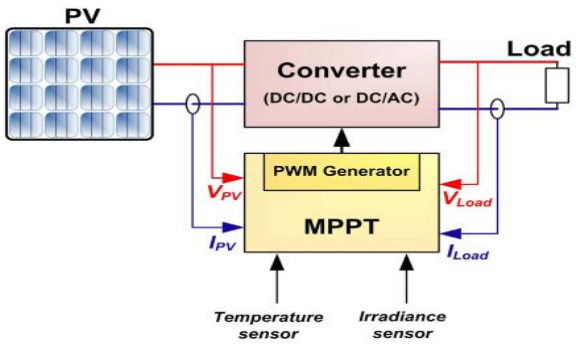


**Fig.1.** MPPT system connected with SPV system

## 2. REVIEW ON MPPT METHODS

As the demand of renewable sources as solar is increased due to its environmental friendly nature and easy to install at any location, there is still some challenges in the converters used in solar power plants. There are three major converters used in solar plants as Buck, Boost and Buck-Boost converters. These converters need to be operated in such a manner that the out-put is as per requirement of system and with improved efficiency.

Literature survey is organized for the study of work done in this field and to get scope of work from that analysis.

**J. Prasanth Ram, et-al** have proposed Maximum Power Point Tracking (MPPT) for removing maximum power is especially appreciated and holds the key in developing efficient solar PV system. A best in class survey on different maximum power point strategies for solar PV systems covering conventional methods and latest soft computing algorithms. The critical analysis on each of the method in terms of (1) tracking speed (2) algorithm complexity (3) dynamic tracking under partial shading (4) hardware implementation is carried out. The over-all review of different MPPT techniques are discussed and their uses are presented. [3]. **Ryan Shun, et-al** Partial-shading is presented within the situation, the voltage-current characteristics of an R-range connected solar panel wires are not similar to a panel. Compared to having a maximum power point (MPP), Ra-Than is committed to a comprehensive literature technique to find GMPP. In any case, these techniques are generally required to know the characteristics of the panel, which include additional detection components and circuits-seats, and / or yield strength. A two-step algorithm is

proposed to monitor GMPP for managing these issues. The first step determines the string voltage on which the GMPP. This de-pends on the separation of the power-voltage characteristics of the string through separating the input impedance of the electrical processing unit to fix the GM-AP-NZL location. The second step determines the exact location of GMPP. [4] **Nabil Karami, et-al** have given the concept of power tracking for PV systems is high-lighted and an overview on 40 old and recent Maximum Power Point Tracking (MPPT) methods, accessible in the literature, is exhibited and characterized. These methods are mathematically model and exhibited in such a way can choose the most proper technique for his own particular application. [5] **Jen-Hao Teng et-al** presented the output power of solar energy radiation and temperature nonlinear. Therefore, maximum power point tracking (MPPT) is very important to find maximum power in real time. The P&O method is basic method of MPPT but limited to trade off selecting perturbation step size the control variables. In this paper proposed parameter estimation MPPT for PV system. The proposed MPPT used parameter estimation calculation of radiation and temperature. The operating voltage maximum power can be find out fasted. This MPPT increased the harvested energy. [6] **Markus Andresen, et-al** proposed that the fast MPPT algorithm can produce higher variable loading of power semiconductor resulting in decreased of system life time. Multi objective MPPT that limits the positive temperature gradient and maximum junction temperature of the power semiconductor. It reduced thermal stress and improved reliability of power electronics components under tested condition reduced 3.7% energy harvesting has increased 13% lifetime. [7]
**M. Seyedmahmoudian, et-al** given a maximize output power to used maximum power point tracking (MPPT). It shows that artificial intelligence (AI) based technique is batter and effective compare to other MPPT techniques. Including their merits and demerits. The recent technique that conducted performance analyses of each method under different conditions were discussed and analyzed. Many kinds of hybrid methods that used to covered artificial intelligence (AI) methods are reviewed in it. [8] **Xingshuo Li, et-al,** presented Maximum power point tracking is useful for photovoltaic system to ensure that maximum output power of solar panels under any atmospherics condition. In the Bata technique were merits in terms of fast tracking speed and steady state performance are simple implemented. The conventional Beta technique can be improved minimized oscillation the maximum power point under steady state and increased tracking speed in response to sudden changed atmospheric conditions. Adaptive scaling factor (ASF) used in the MPPT methods, which enhances the tracking speed. The proposed methods are identify and maintain of middle point of three level perturbations, which eliminated the oscillation at steady state. Two novel MPPT techniques were used. One is adaptive scaling factor (ASF) to improve transient condition and another zero oscillation perturb and observe (P&O) to eliminate steady state error. [9] **Yuxiang Shi, et-al,** proposed PV system consisting of DC-DC converter with cascade multilevel inverter. The system efficiency improved by replacing electrolytic capacitor with film capacitors. A novel variable step size MPPT algorithm is proposed to maximum power extraction sudden radiation change. The proposed control MPPT algorithm and test results are given to approved the converter performance. [10] **Enrico Dallago, et-al** presented a direct MPPT method based on easy way to identified maximum power point of PV source. The algorithm rapidly track the MPP without any erratic behavior. In this capacitor double capacitor interface (DCI) is to charge DC link capacitor with the help of PV generator. Experimental results to perform on breadboard build to test MPPT capability presented. The DCI tracking efficiency estimated to be 97.8% response time faster than P&O method. [11] **Kinattingal Sundareswaran, et-al** gives the P&O technique is very simple to implement to find out maximum power point tracking from PV generating system. However, P & O has failed to identify the global maximum power point (GMPP) technology and to spread the partially shaded conditions (PSC) methods to the local maximum power point (LMPP). New method proposed to hybrid approach ant colony optimization (ACO) and local search capability of P&O method are integrated to faster and efficient. [12] **Kok Soon Tey, et-al** proposed that a fast maximum power point tracking system is required to ensure PV response with minimum power losses. A simple fast converging MPPT technique, which excludes the extra control loop. In this algorithm relationship between load line and I-V, curves are used trigonometry rule to get the fast response. The proposed system only required DC-DC converter and a PIC microcontroller is simple than which required extra load loop and intermittent connection. [13] **Boualem Bendib, et-al** given a maximum power point tracker depends on the solar radiation and cell temperature. There are classified in two categories: there are conventional techniques like P&O technique, incremental conductance technique, Hill climbing method and another advance techniques such as fuzzy logic based MPPT method. It gives the survey of all methods to evaluated, analyzed, and simulate for PV system varying with different weather conditions. Results was shown static and dynamic performance of fuzzy MPPT controller were batter then those of conventional techniques. In this paper survey intelligence techniques were most efficient. They have fast response but they are more complex compare to conventional techniques that are generally simple, cheap and less efficient. [14] **Raseswari Pradhan, et-al** proposed new MPPT for Solar PV by using double integral sliding mode controller (DISMC). A double integral SMC used double integral of tracking voltage error apart from providing robust control actions. The objective of this technique avoid chattering and new sliding surface. The MPPT implemented with PWM controller DC/DC converter switching frequency is constant. Thus designing of filter make to circuit simple. Both simulation and experimental results presented to validate the efficiency of this maximum power point tracking. [15] **Anoni Urtasun, et-al** Presented two input buck converter DC-DC stage conversion for PV system. This

converter is effective because they can achieved maximum power tracking with single power transistor. The nonlinear characteristics as the converter and the two PV system complicated to control. In this paper shown while fast voltage are achieved for first input. The second voltage response depends on second stage converter control. For these converter used system make cost effective and reliable. Dynamic resistances on the control performance was evaluated. It's shown dynamic response becomes slower and operating point move towards the constant voltage region and the stability is ensuring for every situation. [16] **Muralidhar Killi, et-al** proposed an adaptive voltage sensor based maximum power point tracker used with SPICE converter. In this method only voltage divider circuit to used find out the PV panel voltage. This method can improved effectively and improve transient and steady state performance by varying scaling factor as compare to the fixed step size with step scaling factor. For solar radiation start-up to steady state, its leads to lower oscillation around maximum power point. Given a research on steady state, behavior and drift phenomena were addressed and determine the tracking efficiency. A microcontroller is used to digital platform to implement the proposed algorithm for validation. This method improve the efficiency of PV system and reduces power losses in steady state. From results obtained, notice that with a well design system including proper converter an efficient MPPT algorithm. [17] **Abdelhamid Loukriz, et-al** gives an improvement of the efficiency of PV system based new MPPT algorithm due to low cost and easy implantation. Represented new variable step size incremental conductance MPPT algorithm. A comparative study between the variable step size and fixed step size IC MPPT method under similar operating condition were presented. The experiment results shown proposed MPPT a good accuracy, fast converging speed, less oscillation around the MPP. This algorithm is more efficient with better noise rejection and less energy losses. [18] **Mohammad Mehdi, et-al** have given a PV system power generation and partial shading is and reduce the efficiency of overall system. Thus, a reliable technique is required to track to global maximum power point (GMPP) with appropriate time. Presented to employing hybrid evolutionary algorithm called DESPO technique. A combination of DE algorithm and partial swarm optimization (PSO) detect the MPP under partial shading conditions. In this technique, the computational burden of the algorithm are reduced and this technique easily implemented a low cost microcontroller. [19] **Francisco Paz, et-al** considered the maximum power point tracking strategies in PV system for ensure efficient utilization of PV power. In paper among all of these MPPTs one of the P&O method widely used because of simple implementation. The P&O maximum power point tracking have limitations one is create losses that steady state operation and an-other is limited ability to track sudden changing atmospheric conditions. This paper developed zero oscillation and slope tracking to address of the challenges. In this, paper three methods to improved steady state behavior and transient conditions (i) ideal operation of maximum power point (ii) identification actual perturbation (iii) simple multilevel adaptive tracking steps. These methods are identified relevant information to produced efficiency gains. [20] **Kai Chen, et-al** Maximum power point tracking is integral part of energy conversion using PV system. This paper new technique track the global maximum power point (GMPP) of PV system and compared past proposed MPPT. This paper proposed method advantages of determine whether partial shading were presented. The new method quick find GMMP and avoid energy loss due to blind scan. The simulation and experimental results validated to partial shading conditions. [21] **Hegazy Rezk Ali, et-al,** presented the study of behavior of different MPPT techniques with PV system. A model of PV and boost converter with different MPPT techniques were simulated using PSIM and MATLAB software. Simulation between PSIM and MATLAB software is used to fuzzy logic MPPT technique. The response techniques is evaluate in changed weather conditions. The results shows that FLC technique best among compared MPPT techniques. The objective of this paper focused on simulation comparison between different MPPT techniques and understand which techniques were the best performance in maximum power tracking in weather conditions. In simulation results FLC techniques has lower percentage reduction in generated power compared to all other techniques with entire range of duty cycle. To summarize overall performance compared the fuzzy logic controller are superior with respect to other MPPT techniques. It can effectively improve the tracking and minimized steady state error simultaneously. [22] **B. Bendiba, et-al** presented an advanced method of MPPT using fuzzy logic controller for solar PV system. Gives simulation and results compared with the obtain by the P&O and FLC during steady state and varying weather conditions. In this Paper FLC based MPPT controller is developed to identify MPP and regulated the PV array to operate that particular operating voltage. The fuzzy logic controller MPPT better response than conventional P&O controller. [23] **Sathish Kumar Kollimalla, et-al** three algorithms, namely current distortion algorithm, adaptive control algorithms, and variable distortion algorithm. The current disturbance algorithm always tries to operate the photovoltaic panel at MPP. These operating boundaries have been expressed in the context of the current range of PV panel operation and sudden changes in chaos are proposed to be adapted from the inefficiencies in the conventional P & O method, adaptive P & O MPPT algorithm proposed. This technique tracks true maximum power, which is contrary to partial open circuit voltage and FSCC methods. There is no need for a large amount of storage data for training and comprehensive calculation to clear various steps needed by FLC and NN. Simulation and experimental studies show that the proposed algorithm responds faster than conventional algorithms. [24] **Moacyr Aureliano, et-al** have been evaluated the most usual maximum power point tracking techniques done comparisons with respect to amount of power extracted from PV tracking factor, PV voltage ripple, dynamic response and used of sensors. In this paper MPPT algorithms and

improve MPPT algorithms with IC based on PI and perturb & observed based on PI. The dynamic response and the TF are also evaluated using user-friendly interface, which is capable of online program power profile, and compute the TF. The implemented of MPPT algorithm through digital controllers can applied were possible to minimize error functions. This paper contributed choosing good algorithm should implemented. Finally pointed case of cost reduction and case of intensive shading. [25] **Yi-Hua Liu, et-al** presented two fast techniques used and accurate digital MPPT methods for fast charging platform are proposed. By using piecewise line segments or cubic equation to approximate the MPP locus. ANN based program, which can be used to calculate the parameters MPP locus is also developed to propose digital MPPT system. The advantage of proposed system is low commutation requirement, fast tracking speed and high static/dynamic tracking efficiencies. This proposed method can be apply for all power converters and can be easily implemented any type of voltage regulation loop. [26] **Ahmed K. Abdelsalam, et-al** have proposed a high reliability of PV-based micro grids required maximum power point tracking controllers to maximize the energy due to the nonlinearity in PV characteristics. P&O techniques still suffer from several disadvantages such as generated oscillation around the MPP fast tracking versus oscillation trade-offs and user pre-defined constants. A modified P&O MPPT technique applicable for PV systems presented. The proposed technique utilizes rate of change of the PV power and treats it by a PI-controller to generate an adaptive perturb. A modified P&O MPPT technique were presented, which is suitable for a PV-based micro grids. The proposed technique named PI–P&O is generic, adaptive and does not require any pre-set constants like other P&O techniques. It demonstrated that high-performance steady-state operation could be achieved with no oscillations around the MPP using the proposed technique.[27] **Azadeh Safari, et-al** Incremental coupling used in solar PV system with direct control method introduced the MPPT implemented simulation hardware. As a result, the system was able to track MPP correctly and without static state oscillation and dynamic performance satisfying. INC technology has been used for precise control under rapidly changing atmospheric conditions. The proposed system was simulated manufactured and proved the efficiency of the proposed Sam-Troll concept. The results obtained during simulation, hardware X-Patient were confirmed that selecting a proper converter with a well-designed system, and selecting a skilled and proven algorithm was included. [28] **Qiang Mei, et-al** proposed Maximum power point tracking is widely used for PV sys-tem to generated maximum power which depends upon solar irradiations. Among all these MPPT, the INC algorithm is widely used for high tracking accuracy. Give a new variable step size incremental resistance MPPT introduced which not only has merits of INC but also automatically adjusted the step size to track the PV system. The proposed method can improve the MPPT response speed and steady state accuracy of PV system. [29] **Anil K.Rai, et-al** Simulation model of the maximum power point tracking controller based on Artificial Neural Network (ANN) has given. The ANN tracker estimated the voltage and currents maximum power delivered by solar PV array for cell temperature and solar radiation. The ANN tracker is trained 124 patterns used propagation algorithm. The mean square error of tracker output set to order of 10-5 and take learning process take 1281 epochs. It shows that ANN performance better than PID controllers show and avoid the tuning of controller parameters. [30] **Maria Teresa, et-al** proposed new maximum power point tracking method focused on low power PV panel. A prototype was implemented 500mW PV panel with boost converter. Tracking efficiency was higher than 99.6% the overall efficiency higher than 92% for a PV panel power higher than 100mW. The response of the tracking was tested around 1s and temperature was 26 degree. Higher gain expected for lower temperature. [31] **Fangrui Liu, et-al** have shown Maximum power point tracking used in PV system find out full maximum output power, which depends on solar irradiation and temperature. All MPPT techniques the incremental conductance technique is used to high tracking accuracy at steady state to rapidly changed atmospheric conditions. Modified variable size INC MPPT algorithm is used. Which is automatically adjusted step size to track the PV array MPP. In this INC technique easily implemented in digital signal processors. A simple CVT programme is introduce to the MPPT algorithm which enable to smooth start process both fixed and variable size INC MPPT were implemented. [32]

Numerous techniques are used to estimate the maximum power tracking of solar PV system. Which are shown in Table 2.1

Table 2.1 Analysis of different MPPT techniques

| Methods | Tracking Speed | Complexity | Hardware Implementation |
|---|---|---|---|
| P&O | Normal | Low | Easy |
| INC | Normal | Low | Easy |
| FLC | Average | High | Moderate |
| NN | Average | High | Moderate |
| PSO | Normal | Moderate | Moderate |

## 3. CONCLUSIONS

In perspective of the significance of control methodologies in overall the proficiency of the PV system, this paper concentrated on the unique approaches in following the MPP of PV system. The review is performed on most generally utilized techniques before a long time the benchmarked in MPPT implementation. To total up, the complexity associated with every algorithm and dependable performance of Evolutionary algorithms under powerful climate conditions are quickly analyzed. Moreover, inside examination bargains with design consideration, performance analysis, accuracy, and hardware implementation process has been conveyed out. From the overview, it is evident that as of developed Swarm

optimization technique and Fuzzy logic control technique have gained positive gathering as far as accessibility and convergence.

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