REVIEW OF MAXIMUM POWER POINT TRACKING APPROACHES SUITABLE FOR PHOTOVOLTAIC SYSTEM

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ABSTRACT: In solar photovoltaic (PV) generation, maximum power point tracking (MPPT) techniques are fundamental especially as they grow in size and are subjected to varying climatic conditions. In photovoltaic (PV) systems, maximum power point tracking (MPPT) approaches are used to maximise the PV array output power by continually tracking the maximum power point (MPP), which is dependent on panel temperature and irradiance conditions. A significant amount of research has been conducted in attempt to develop more efficient MPPT. On the basis of development, this study explores maximum power point tracking strategies.

INTRODUCTION: Under uniform irradiance, a photovoltaic (PV) array's current-voltage characteristic has a single point, known as the maximum power point (MPP), where the array provides the most output power. In order to maximize the power production from a PV system under a particular set of operational parameters, the MPP must be tracked continuously.

Precisely for low-cost implementations, perturb and observe (P&O) and incremental conductance (INC) approaches are extensively used though there are many approaches available.

The P&O MPPT algorithm is widely implemented because of its simplicity. The disadvantage of the P&O MPPT technique is the operating point oscillates about the MPP at steady state, resulting in the loss of some available energy. Many P&O algorithm enhancements have been developed to lower the number of fluctuations around the MPP while stable condition, however they slow down the algorithm's response time to fluctuating environmental parameters and lessen the method's efficiency on overcast days. The INC algorithm aims to address these issues. It is a simple procedure with better transient performance. There are many methods of MPPT shown in table 9. A block diagram of a single-stage solar energy conversion system (SECS) is shown in Figure No. 31, and a dual-stage energy conversion system (SECS) is shown in Figure No. 32. The MPPT is used extensively in SECS to track the maximum power point to get maximum output.

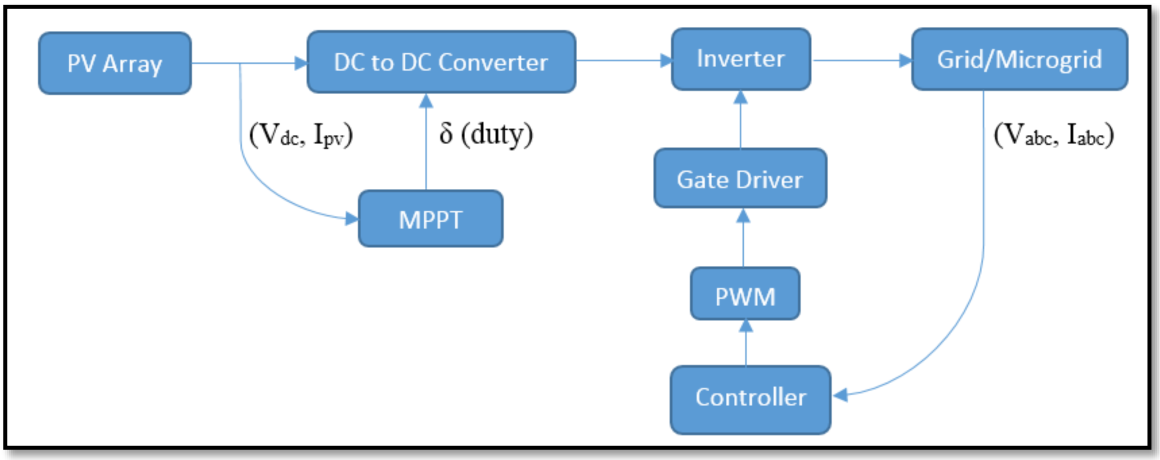

Figure 30: Dual stage solar energy conversion system.

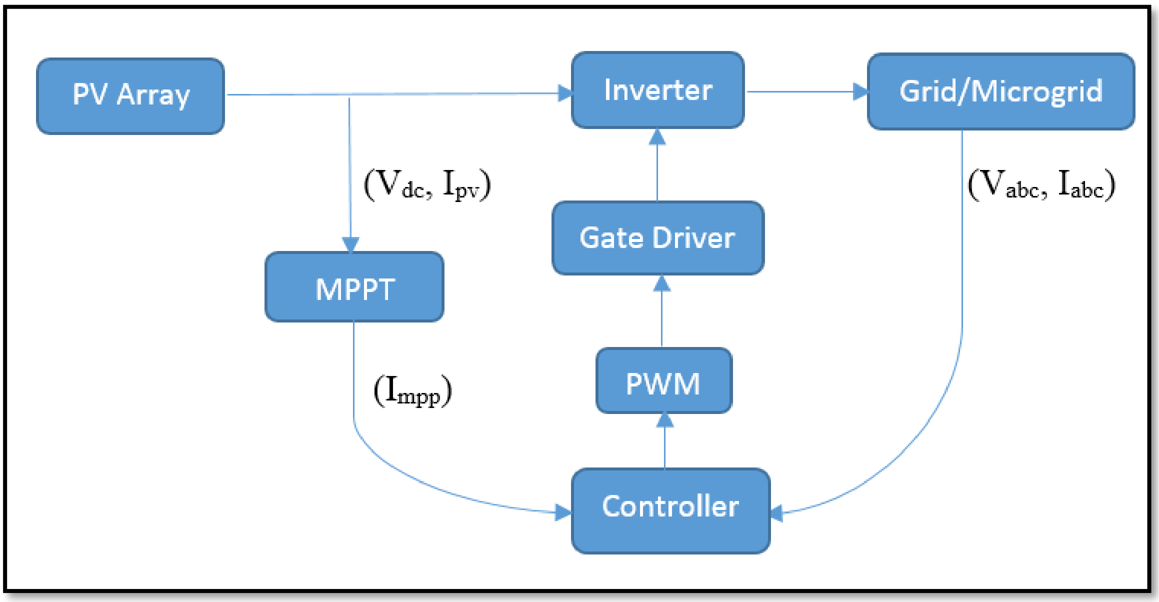

Figure 31: Single stage solar energy conversion system.

OBJECTIVE: The main aim of this study to explores maximum power point tracking strategies and classification of different MPPT algorithms depending upon their working principle

LITERATURE REVIEW: When insolation and temperature change, photovoltaic systems often use a maximum power point tracking (MPPT) technique to continually send the highest feasible power to the load. It solves the problem of solar arrays that aren't matched to the load. Solar radiation, ambient temperature, and solar cell temperature all affect maximum power. (Enslin, 1990) [5] has described an industrialized MPPT regulator, along with some evaluation findings and a simple cost analysis. Finally, it can be argued that MPPT procedures, especially for smaller Remote Area Power Supply (RAPS), are cost-effective and, in some situations, necessary for precisely sizing RAPS. (Enslin& Snyman, 1991) [6] have given a new approach for increasing the efficiency of a maximum power-point-tracker. They have introduced described, and evaluated compound power converter for photovoltaic systems as a high frequency dc-ac inverter, an MPPT, and a battery charger. Then (Siri et. al., 1993) [7] have developed Maximum power point control scheme which is capable always look for peak power flow without needing to know the non-ideal source's characteristics. (Enslin et. al., 1997) [8] proposed Maximum Power Point Tracker (MPPT) which has increased in efficiency and cost effective than previous MPPT. (Hua et. al., 1998) [9] have suggested a control algorithm that only requires two sensors and uses power as the control variable based on the perturbation and observation approach. Increase the execution speed to get a better reaction for the system amid quick atmospheric condition changes. A low-cost, low-power consumption MPPT system for battery charging has been developed and evaluated by (Koutroulis et. al., 2001) [10] in their article. A Buck-type dc/dc converter with great efficiency and a microcontroller-based unit that controls the dc/dc converter directly from PV array output power measurements make up the system. Traditional two-stage PV energy conversion systems are bulky, expensive, and inefficient, making them unsuitable for use in small-scale PV energy conversion. To address this issue, (Kuo et. al., 2001) [11] have proposed a PV energy conversion system with a single-stage architecture. Advanced features of the suggested single-stage system include a small physical volume, low weight, and great efficiency. For quick tracking of the PV array's maximum power point, a unique single-stage MPPT controller is implemented. The suggested technique considerably improves tracking by reducing oscillation. When insolation is adequate, the proposed PV energy conversion system provides solar generation, and when insolation is insufficient, it provides active power line conditioning. The transition between the two modes is smooth and consistent. (Veerachary et. al., 2002) [12] developed a current sensor less (Solar Cell Array) SCA voltage based on an MP point tracking method for a (Interleaved Dual Boost) IDB converter supplied PV system. A short-current pulse-based adaptive MPPT approach for PV power generation systems has been described by (Noguchi et al., 2002) [13]. The approach makes use of a proportional relationship between the short current and the PV's optimum operating current. Furthermore, the suggested system incorporates a proportional parameter identification technique to make the MPPT algorithm resistant to disturbances like as shading and surface pollution on the PV panels. The short-current pulse-based MPPT algorithm is adaptable to many environmental scenarios because the relationship between the short current and the optimum operating current may be considered linear even though both temperature and irradiance simultaneously vary substantially. For the interleaved dual boost (IDB) converter supplied PV system, (Veera chary et. al., 2002) [14] established a fuzzy feed forward voltage-based MP point tracking approach. The PV source and converters are given analytical expressions. For on-line estimate of reference voltage for the feed forward loop, an off-line ANN trained using the back-propagation approach is used. (Tse et. al., 2002) [15] proposed a method for determining the maximum power point (MPP) that involves injecting a small-signal sinusoidal disturbance into the switching frequency and comparing the ac component with the average value of the panel terminal voltage. Apart from not requiring any complex digital panel power computations, the suggested technique does not approximate panel characteristics and can locate the MPP globally under a wide range of insolation conditions. (Veera chary et al., 2003) [16] proposed a fuzzy controller-based feedforward MP-point tracking technique for the coupled-inductor interleaved-boost-converter-fed PV system. In comparison to the non-coupled converter system, the suggested converter has reduced switch current stress and higher efficiency. The tracking algorithm alters the duty ratio of the converter for a given solar insolation so that the solar cell array voltage equals the voltage corresponding to the MP point. The feedforward loop does this by comparing the instantaneous array voltage and the reference voltage corresponding to the MP point to generate an error signal. The fuzzy controller creates a control signal for the pulse width-modulation generator, which modifies the duty ratio of the converter, based on the error and change of error signals. The reference voltage corresponding to the MP point for the feedforward loop is obtained by an offline trained neural network. Experimental data are used for offline training of the neural network, which employs a backpropagation algorithm.

MPPT Methods	Advantage	Disadvantage	Improvement methods	References
Perturb and Observe and Incremental conductance	simple approaches, cost effective	oscillation in steady state, simultaneous optimization (optimising multiple variables at the same time), MPPT drift	zero-oscillations methods, variable-step size methods, drift-free methods	[17]-[19]
Fuzzy logic control	excellent performance in a variety of climatic changes	need designer's depth understanding of the system	design simplification by reducing the number of fuzzy rules. parameter optimization	[17], [20]-[23]
Curve-fitting	good precision	particular measurements are required	parabolic prediction, parameter estimation	[17], [24]
MPP-locus	an excellent	the tracking	employed	[17], [24]-

method	result in the context of a changing weather	technique is still not comprehensive enough	additional voltage line and maintain at voltage line	[26]
Beta method	characterized by step size	parameter optimizations	validation of bounding rang optimization of corresponding parameters	[17], [24]

Table-9. **PV MPPT algorithms are classified depending on their working concepts.**

(Konstantopoulos, C., & Koutroulis, E. 2014) [27] proposed a new way for tracking the global MPP of adaptable PV modules. With fewer search steps, the technique suggested in this paper can determine the global MPP of an adaptable PV module. As a result, the power generation of the adaptable PV module is maximized while the energy dissipation during in the global MPPT method is minimized.

For photovoltaic generation systems (PGS) operating under complex partial shadowing situations, a new global maximum power point tracking (GMPPT) technique is suggested by (Ye et. al., 2022) [28]. The current GMPPT technique is based on the Nelder-Mead (NM) simple technique, which is widely used to tackle complex optimization problems and has features such as ease of implementation, derivative-free nature, rapid convergence, and high accuracy. (Tafti et. al., 2022) [29] proposes a global flexible power point tracking (GFPPT) technique for Photovoltaic system under partial shadowing conditions. (Constant power control) CPC and (power reserve control) PRC are two capabilities of the algorithm that are necessary for frequency assist in Photovoltaic system. In table no-1 PV MPPT algorithms are classified depending on their working concepts.

DISCUSSION: Numerous MPPT methodologies for extracting the maximum power provided by PV modules in various PV systems have been outlined. Perturb and Observe (P & O), Fractional Short Circuit Current (FSCC), Incremental Conductance (INC), and other MPPT techniques are frequently utilised. Artificial Neural Networks (ANN), Fuzzy Logic Method, and Particle Swarm Optimization are some of the more advanced soft computing-based MPPT methodologies (PSO). Though there are many advanced methods developed to track the maximum power point, they still suffer from different drawbacks such as low accuracy, complexity, etc.

CONCLUSION: Many MPPT approaches are studied and classified in this study. MPPT approaches are thoroughly investigated. There has been a lot of effort put into improving the traditional MPPT procedures. There's also an outline of the importance and development of these MPPT approaches. It is clear that the research on MPPT approaches is ongoing. As a result, it is advised that future work be done to adapt soft computing based MPPT, preferably work under partial shading and load variance.

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