International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Review on Maximum Power Point Tracking System on Solar Panels

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ABSTRACT

This paper presents brief information about MPPT methods and techniques. Currently, 70% of the world's energy needs are met by traditional resources, including fossil and nuclear fuels, natural gases, etc., all of which were on the verge of extinction. Therefore, it is preferable to transition to alternative energy sources as solar, tidal, geothermal, wind, biomass, etc. Solar panel power generating is a cheap, popular, and essential approach used all over the world for power generation today. The creation, development, and management of solar plants have become simple tasks as technology has improved. It can be installed from KW to MW loads as per load requirement, but the efficiency of the solar panels is very low, as the power output of the solar panel depends on solar light irradiation received by the panel, solar panel temperature, and weather conditions. Therefore, it becomes essential to extract the maximum power parameters from the PV solar panels using a maximum power point tracking system. It is used to maximize the power output of the solar panels irrespective of solar irradiation conditions, temperature, and load electrical characteristics.

Keywords: Photovoltaic System, Maximum Power Point Tracking (MPPT), solar cells, PV Systems, Solar module, etc.

1. INTRODUCTION:

In light of the recent rise in demand for electric energy, there are several sources available for its production, the percentage of resources used for electrical power generation in India was shown in Fig.1. However, there are also production-related limitations, such as the impact of pollution and the warming of the planet. These limitations drive into research toward the creation of clean and renewable energy sources. One of the most suitable forms of renewable energy is photovoltaic solar energy. Despite becoming increasingly effective, solar panels still offer very modest yields. Because of this, we must reduce energy losses in order to utilize the full power that they can provide [1].

Solar photovoltaic (PV) cells are utilized with power electronics converters to transform solar energy into controlled electrical energy. These solar PV cells have relatively poor efficiency and nonlinear properties. Under different climatic conditions, such as partial shade, the characteristics of solar cells grow more complicated. These problems make it crucial for researchers to maximise the output from solar PV cells under unpredictable atmospheric conditions. Using the maximum power point tracking (MPPT) technique, solar PV modules' output may be increased to its full potential.

In order to extract the true MPP of the PV panel, the duty ratio of the DC-DC converter is controlled using a number of MPPT strategies that have been proposed so far. This goal is accomplished when the PV panel's real load line and the load at which the PV panel is drawing its greatest amount of electricity coincide. Most often, four common types of DC-DC converters Boost, Buck, Buck-Boost, and Cuk converters are employed for this purpose.

Few of the most popular techniques are [5]:

1) Perturb and observe (hill climbing method)
2) Incremental Conductance method
3) Fractional short circuit current
4) Fractional open circuit voltage
5) Neural networks
6) Fuzzy logic

1.1 Perturb and Observe method (Hill climbing):

Perturb & Observe is the easiest method (P&O). Since we only need one sensor, a voltage sensor, to detect the voltage of the PV array, it is inexpensive and straightforward to construct. Although this approach has a very low time complexity, it continues to perturb in both directions even when it is very close to the MPP. If this happens, the algorithm is very close to reaching the MPP, and we may either set an appropriate error limit or use a wait function, which makes the procedure more time-consuming. However, the technique ignores the abrupt changes in irradiation level and interprets these as perturbation-related changes to MPP, which leads to incorrect MPP calculations. We can utilize the incremental conductance approach to get around this issue [5] and [6].

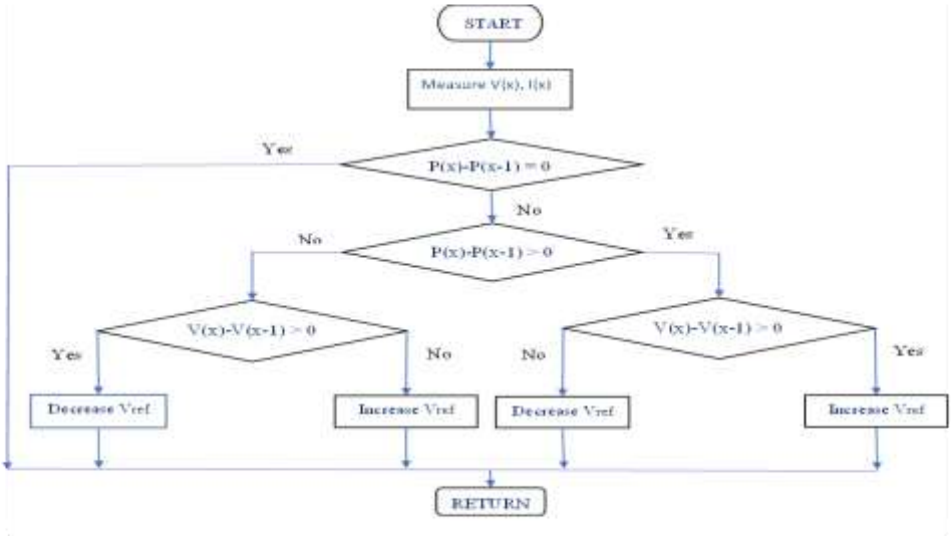

Fig.4: - Flowchart of the P&O algorithm [5] and [7].

1.2 Incremental Conductance method:

The incremental conductance approach, which involves use of two voltage and current sensors, is used to measure the PV array's output voltage and current. Here, we are measuring both the voltage and the current at the same time. As a result, the error brought on by a change in irradiance is fixed. However, the complexity and expense of implementation increase. As we proceed down the list, the algorithms' complexity and execution costs keep increasing, which may be suitable for a very complicated system [3] and [7].

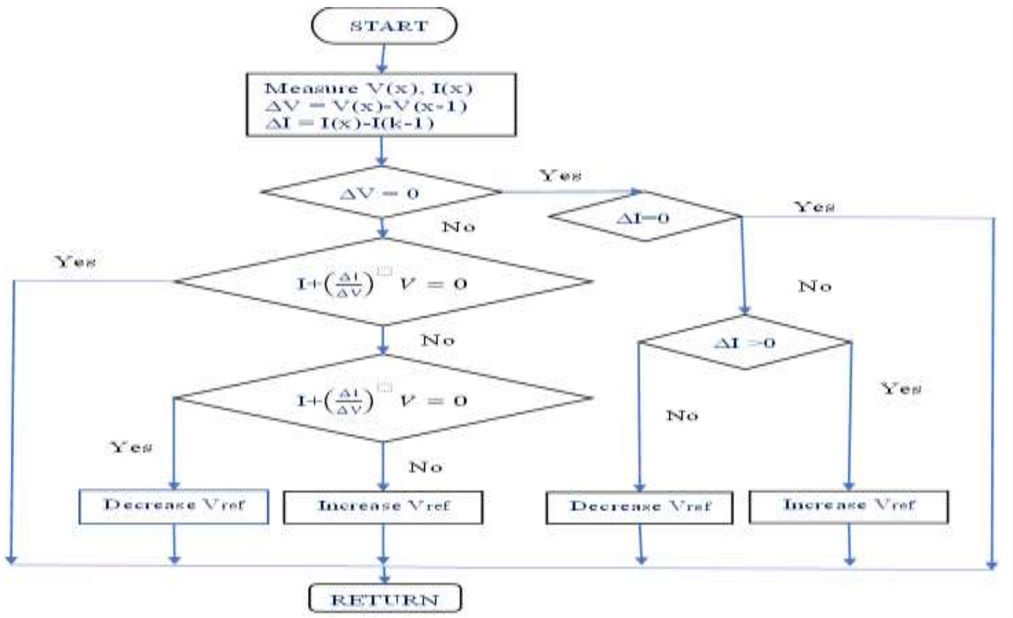

Fig. 5. Flowchart of ICC method [3]

1.3 Fractional short circuit current method:

This technique, which is quite similar to the FOCV, determines Iopt by measuring the PV's Isc. Following is a relationship between short circuit current and ideal current:

$I_{opt} = I_{sc}. V_{sc}$ $(0 < k_{sc} < I)$

Here, the ksc coefficient is dependent on the same variables. In most cases, 86% of the open circuit current corresponds to the ideal current. According to studies, the ksc value is between 0.78 and 0.92 [8]. Because of heat dissipation and an increase in power loss, it is more challenging to determine Isc in FSCC, whose flowchart is given in Fig. 6. The system might not always be physically susceptible to being shorted out. Additionally, extra components like switches and current sensors can be required. The price and energy production loss will rise as a result. For these reasons, the FOCV is chosen above these two straightforward techniques.

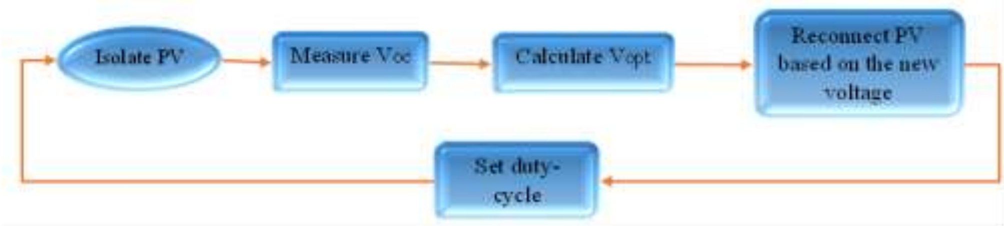

Fig. 6. Fractional short-circuit current method flowchart [5]

1.4 Fractional open circuit voltage:

The PV panel open circuit voltage is expressed by the Voc in Fig. 6. In the FOCV, the Vopt is calculated by measuring the Voc at the ends of the PV panel and multiplying it by a certain coefficient. The formula for the relationship between Voc and Vopt is as follows:

Vopt = Voc * koc $(0 < koc < 1)$

Here, the koc coefficient is influenced by variables like the panel's manufacturing method and the environment. Typically, 76% of the open circuit voltage is the ideal value. The koc value is between 0.73 and 0.80,[8] according to studies. The main drawback of the approach is that to measure the Voc, the PV power must be abruptly shut off (see Fig. 6's flowchart). Due to its inexpensive cost and straightforward implementation, it is favored in various situations.

1.5 Artificial Neural network method:

ANN typically have three layers. The first layer, known as the input layer, designates the location of the data collection, the second layer, known as the hidden layer, designates the location of the data processing in a complex structure, and the third layer, known as the output layer, designates the location of the results. Fig. 7. depicts the fundamental design of artificial neural networks. PV module metrics like Isc, Voc, temperature, radiation, atmospheric measurements, or other combinations of these may be used as input data in neural networks. At the output, duty cycle information for the DC-DC converter is collected. It may take days or years to identify the best weights in this approach since incoming data are processed with specific weights in the hidden layer. Each network structure was developed using the PV system as its training data, hence it cannot be used with another system. However, a system's network training enables the system to operate in genuine MPPT without being impacted by changes in the PV module's characteristics or outside variables [8].

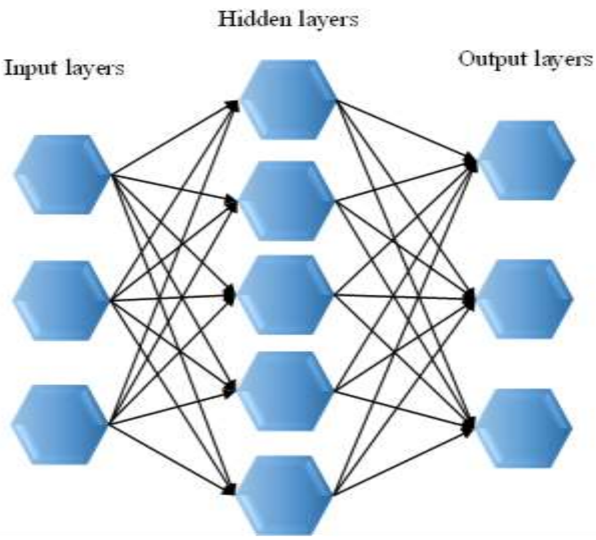

Fig.7. Artificial neural network method [8]

1.6 Fuzzy logic method:

Fuzzy logic control now has a wider range of applications because of advancements in processor technology. The usage of FL for MPPT offers a number of benefits. Some of them need unexpected, non-modeling physical data as well as the ability to function independently from the system model and follow the MPP with high accuracy while being unaffected by input disturbances. There are three steps in the FL technique. The membership function is used in the first stage, fuzzification, to translate numerical values into linguistic values [8].

Conclusion:

To extract the maximum power and efficiency out of the PV panel, many MPPT algorithms have been presented throughout the years. These techniques have both numerous benefits and drawbacks. The best application strategy for the PV system must be chosen. Here, a number of factors should be taken into account, including the area's atmospheric conditions, the length of the sun's rays, and the budget set aside for the system. In this study, the most popular techniques were analysed and contrasted in light of specific factors. The algorithms are contrasted in Table-1. Major factors including speed, stability, cost, efficiency, etc. were taken into consideration throughout the comparison. Voltage (V), current (I), temperature sensor (T), analogue (A) and digital (D) are all used in this context [1, 3, 6, 8].

Tracking Method	Sensors	Stability	Analog/ Digital	Speed	True MPPT	Cost	Efficiency
P&O	V&I	LOW	Analog/Digital	LOW	YES	MID	MID
ICC	V&I	MID	Digital	LOW	YES	MID	MID
FOCV	V	LOW	Analog	MID	NO	LOW	LOW
FSCC	V	LOW	Analog	MID	NO	LOW	LOW
ANN	V&I	HIGH	Digital	HIGH	YES	HIGH	HIGH
FL	V&I	HIGH	Digital	HIGH	YES	HIGH	HIGH

Table. 1: - Comparison between different Tracking methods [1, 3, 6, 8].

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