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A Review and Analysis of Smart MPPT Techniques (algorithms) for Photovoltaic System

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ABSTRACT: In this paper we are discus literature reviews of different MPPT algorithm for photovoltaic system. Now a day's Solar energy is becoming increasingly attractive as we faced with global climate changes & less availability of fossil fuel in India. Solar energy is free, non-polluting, and inexhaustible & we can generate at load site so transmission cost & losses is nil. A solar panel receives the most sunlight when it is perpendicular to the sun's rays, but the sunlight direction changes regularly with changing seasons and weather. Currently, most solar panels are fixed, i.e., the solar array has a fixed orientation to the sky and does not turn to follow the sun. To increase the unit area illumination of sunlight on solar panels we can track the panel such that it can receive maximum sun rays. This work is done to get the maximum power from the solar energy by studying different MPPT algorithms .This paper comprehends the most commonly implemented algorithms such as P&O, Incremental Conductance, Ripple Correlation Control and also some intelligent control algorithm such as ANN & Fuzzy logic**.** The MPPT algorithms are defined and compared in a tabular form.Perturb and observe (P&O) technique gives excellent results and thus is used. This work involves the design of MPPT charge controller using DC/DC buck converter and microcontroller Advantages of both algorithms are achieved.

KEYWORDS: Sun tracker, MPPT (Maximum Power Point Tracking), Solar Cell, PV System.

I. INTRODUCTION

Day by day increasing demand of energy where renewable energy play vital role to fulfil demand of energy. The sources of renewable energy are Solarenergy, wind energy, biomass, Tidal etc [3]. Out of these sun is prime source of energy. We can get electricity by using photo voltaic, photo-thermal process. Photovoltaic is the process to convert light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, electric current results that can be used as electricity. Photo-Thermal process intensity of solar radiation varies with time and the temperature of water raises depended on the amount of solar radiation & high pressurizes steam drives turbine produces electricity.[6] The amount of energy obtain from PV panel is directly proportional to the amount of sun light received by that solar panel. As domestic and industrial application of solar energy is increased, that needs to extract maximum power from solar panel. Three factors that affect the efficiency of collection process are solar cell efficiency, intensity of sun radiation and storage technique. But as because of material used for the manufacturing of solar cell, it is difficult to improve the efficiency of the solar cell, hence it is necessary to improve efficiency of collection process.

There are three methods by which efficiency of collection process can be improved and these are: sun tracking, maximum power point tracking method, and both in MPPT technique we know maximum power is transfer from source to load when source resistance is complex conjugate to load resistance but complex nature of I-V characteristics of solar panel we required to add such complex resistance at the load side to get maximum power & these is achieved in MPPT technique [7].In solar tracking system we used movable panel such that they can track the sun position by open loop or closed loop system. In open loop system we can move the panel by motor at fixed time interval &in closed loop system some feedback mechanism is used to take sun position & panel always faces sun [9].These methods need some intelligent algorithms to track the load and intensity of sun light.

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1.1 Block diagram of PV system:

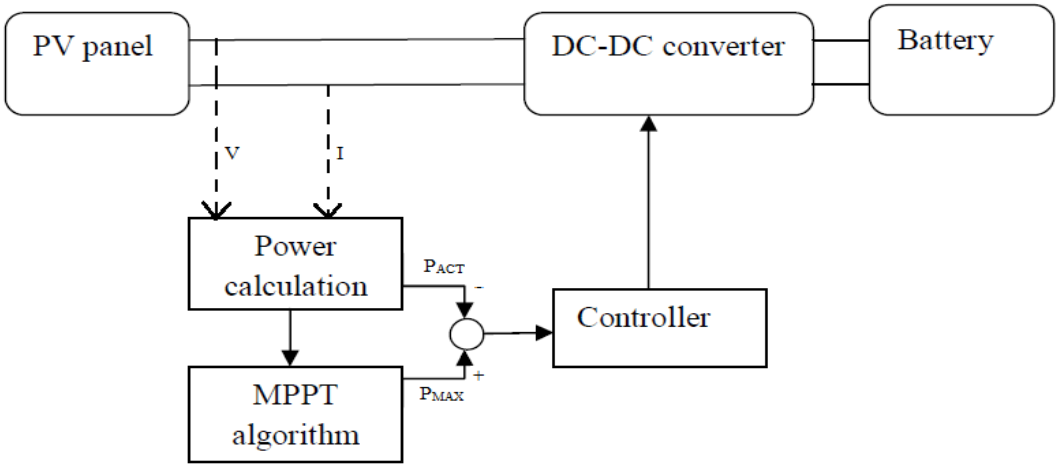

Figure.1 Block diagram of PV system

The PV system comprises of PV (Photo Voltaic) module, DC to DC converter, controllers and batteries as shown in Figure 1. The PV module consists of many solar cells connected in series. The electrical equivalent circuit of solar cell is shows in Figure 2. Usually, for small system, batteries are connected directly as load, whereas for large systems, [1]synchronized line inverters are used for direct interfacing with mains grid. In simple systems a switching device is used to stop the charging when the battery is fully charged. The sensing of full charge status is determined by the battery voltage. To attain maximum efficiency, MPPT charge controllers are used in PV system.

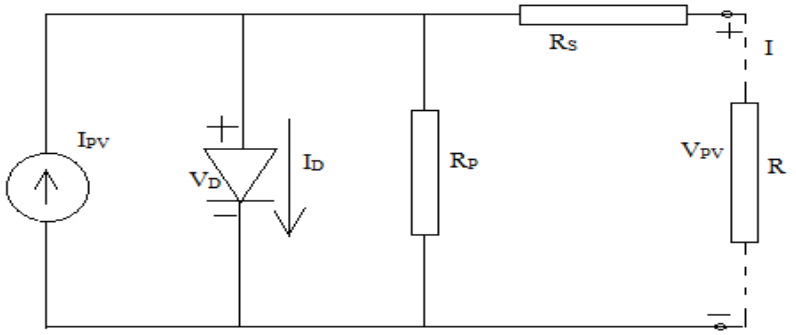

Figure 2. Equivalent Electrical circuit of Solar Cell

It was briefly mentioned above that MPPT are required to guarantee the maximum power output. It is necessary to implement MPPT algorithms as can be seen from the Power - Voltage curve below.[5] The P-V curve is non-linear and hence maximum power output can be obtained by selecting the maximum power point in the output characteristics of SPV. For a 24V system, maximum power point would be around 37V.[1]

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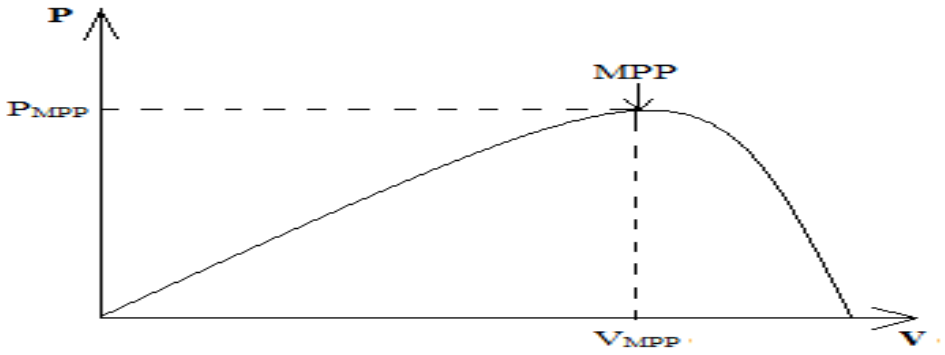

Figure 3. P-V characteristic of solar cell

The point depicted in the above figure is called a MPP (Maximum Power Point) and it is determined mainly by temperature of panel and irradiance condition [6]. The irradiance may change frequently due to clouds or shadow of any object and fluctuate the MPP. An algorithm which continuously computes the operating point of the solar panel is used to fix this dynamic operating point at the maximum power point.[5] These are called MPPT (maximum power point tracking) algorithms[8].To obtain maximum available power, the operating point must be tracked accurately in all condition by using MPPT algorithm.[1] In , the MPPT not only increases the power delivered to the load but also increases the life span of the PV system. In the MPPT system, the duty cycle of PWM based dc-dc converter adjusted to obtain the maximum power point.[2]

II. MAXIMUM POWER POINT TRACKING (MPPT) TECHNIQUES:

1.2.1 Perturb and observe (P & O) algorithm:

The Perturb and Observe Maximum Power Point Algorithm is based on the principle that on the right of the MPP, if voltage increases, power decreases then in this situation perturbation ismade on the reverse direction whereas towards the left of MPP,[4]if increasing the voltage, power also increases then perturbation should be made in same direction. The operation of perturb and observe algorithm as below.

S.No.	ΔP_{pv}	ΔV_{pv}	V_{pv}(ref.)	Duty Ratio
1.	>0	>0	↑	↓
2.	>0	<0	↓	↑
3.	<0	>0	↓	↑
4.	<0	<0	↑	↓

The main drawbacks of Perturb & Observe algorithm are, due to the oscillation of operating point in the MPP region accessible energy is wasted and also it is unable to track maximum power point under varying weather conditions. To overcome these disadvantages, FLC algorithm is implemented to minimize oscillations near operating point and hence energy wastage is also minimized in PV system.

1.2.2 Incremental conductance (I.C) algorithm:

Incremental conductance Technique is based on power- voltage characteristic, the slope of P-V curve is zero at the MPP, positive on the left side and negative on the right side . The drawback of the P&O method (i.e, oscillation of operating point in varying irradiance condition) is eliminated by IncCond. Method. This is a further improvement on the P&O algorithm. The Incrementalconductanceacknowledges that the MPPT has reached at MPP and stops

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perturbing the output voltage The PV array operation is maintained at this point until output current is unchanged. In this technique to track the new MPP, the is increases or decreases.

$$dP/dV = d(V.I)/dV = I + V\,dI/dV = 0$$

$$\begin{cases} dp/dv = 0 \\ dp/dv > 0 \\ dp/dv < 0 \end{cases} \quad \mathbf{1}$$

$$\begin{cases} \Delta I/\Delta V = -I/V & \text{At MPP} \\ \Delta I/\Delta V > -I/V & \text{Left of MPP} \\ \Delta I/\Delta V > -I/V & \text{Right of MPP} \end{cases} \quad \mathbf{2}$$

Thus MPP can be achieved by comparing the instantaneous conduction to the incremental conductance ( ). In this method the array terminal voltage is adjusted according to the MPP voltage, It is based on the incremental and instantaneous conductance of the PV module

1.2.3 Ripple correlation control (RCC) technique

In PV system, PV array is directly connected to a power converter, which is basically a switching device. The switching action of the converter imposes voltage and current ripples on the PV array. Hence, we can say, that the power generated from PV array is related to ripples. In [35, 36], the Ripple correlation control method ripple are utilized to track MPP. The switching converter has ripple naturally so that there is no need to generate perturbation artificially [2].
The **method** which makes use of such **ripple** and correlates this with switching function to **control** the operating point of PV array is called **ripple correlation control** (**RCC**).
RCC correlates time derivative of power

1.2.4 DC-link capacitor droop control technique

This technique isdeveloped for the system where PV system is connectedparallel with AC system line [39, 40]. The duty cycle of boostconverter is defined as in (12).

$$\boldsymbol{D = 1 - V/V_{link}}$$

Where Vthe output voltage of PV is array and $V_{link}$is the voltage across the DC link. In this technique for fixed DC link voltage V_{link}, the output power of boost converter increases b yincreasing the current going in to the inverter and hence it will also increases the output power of PV array [5]. The voltage $V_{link}$is kept constant with increasing current until the power required by inverter is less than maximum power provided by the PVarray. If the required power by inverter further increases and exceed the level of maximum power present at PV array, the V_{link}starts to decrease. Just before this condition the output current is at maximum value (I_{max}) and PV array is at MPP. The duty cycle of converter is set for(I_{max}) and AC system line current is fed back to avoid drooping ofV_{link} , thus MPPT is performed.

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1.2.5 Artificial Intelligence

An Artificial Intelligence (AI) MPPT technique in PV system achieve very good performance and fast responses especially for rapid temperature and irradiance variations. In present time AI technique is implemented in different areas. This paper considers only artificial neural network (ANN) and Fuzzy logic (FL) method out of the many existing AI techniques for MPPT.[1]

Artificial Neural Network– An Artificial neural network (ANN) consists of electrical neurons which are connected to each other depending on different topologies. An ANN uses non linear and complex function for identification and modelling of the system. A neural network consists of three layers as shown in fig. 7. The PV data such as open circuit voltage and short circuit current or atmospheric irradiance and temperature may be used as input. The output signal is the duty cycle signal for power converter to operate at MPP. The exact knowledge of PV system parameter is not required, which is a major advantage of ANN

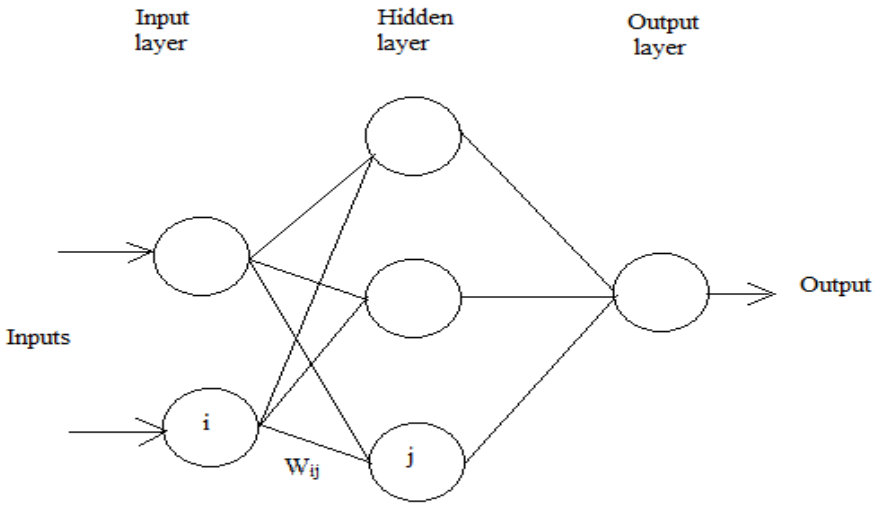

Figure 4 Example of neural network

The node ‘i’ and node ‘j’ are connected through weighted link ‘Wij’ as depicted in the figure 4. The weight Wij must be determined carefully to track MPP precisely, using relations established between input and output of PV system through the process of training.[1] The characteristic of PV module changes with time, so the weights must be updated accordingly to achieve MPP, and this process is termed as an adaption cycle.The closeness of operating point and MPP depends on the algorithm used by hidden layer. The number of nodes in each layer depends on the user.

1.2.6 Fuzzy Logic based MPPT technique –

Fuzzy logic is a method that does not require a precise mathematical model. Fuzzy logic executes linguistic variable computing method rather than the precise numerical digit numbers, and fuzzy controller is more robust compared to the conventional non-linear controllers. Fuzzy logic control primarily has: fuzzification, rule base table lookup, and defuzzification.[4]

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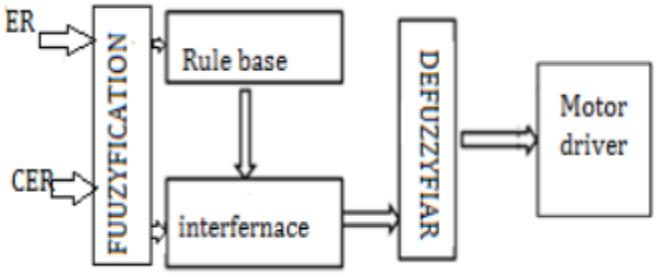

Figure 5. Block diagram of fuzzy logic controller

Here the inputs Error(Err) and change in the error(CE) getting from the sensor. This inputs converted into the fuzzy input and output will get after fuzzification.[1] This output is then fed to the motor to control it. As shown in above figure.5.

1.3 Comparison of MPPT Algorithm:[6]

MPPT TECHNIQUE	PV ARRAY DEPENDENT	TRUE MPPT	ANALOG OR DIGITAL	COMPLEXITY	SENSED PARAMETERS
P/O METHOD	NO	YES	BOTH	LOW	VOLTAGE,CURRENT
INCREMENTAL CONDUCTANCE	NO	YES	DIGITAL	MEDIUM	VOLTAGE,CURRENT
RIPPLE CORRELATION CONTROL (RCC) TECHNIQUE	NO	YES	BOTH	LOW	VOLTAGE,CURRENT
DC-LINK CAPACITOR DROOP CONTROL TECHNIQUE	NO	NO	BOTH	LOW	VOLTAGE
ARTIFICIAL INTELLIGENCE	YES	YES	DIGITAL	HIGH	VARIES
FUZZY LOGIC CONTROL	YES	YES	DIGITAL	HIGH	VARIES

III. CONCLUSION

In this review paper, most widely used MPPT technique are discussed such as perturb & observe, incremental conductance, fuzzy logic control, artificial intelligence etc. All discussed MPPT techniques are compared on the basis of complexity, cost, sense parameter and conversion speed. Further we will implement and analyse one of the technique and compare its results with another techniques on the basis of above parameters.

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