A review of Maximum Power Point Tracking techniques for Photovoltaic system

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***Abstract*—This Paper introduces a review of MPPT techniques for photovoltaic applications. The solar radiations are variable, it varies throughout the day so tracking of solar rays is difficult for achieving peak power. So adaptive voltage sensor based method enhance the transient and steady state factor. This paper discusses about various previous conventional topologies as well as proposed adaptive topology. The proposed system can track maximum power and employs drift free phenomenon. The conventional methods are costly and complex whereas proposed has simpler and less costly. The proposed method can improve the efficiency of PV model and reduces power loss in steady state.**

***Index Terms*—Voltage sensor, Maximum power point tracking,SEPIC converter,photovoltaic.**

I. INTRODUCTION

Renewable energy is most powerful source to generate electrical power because it has less maintenance, it cannot produce any noise, and it has pollution free. The principle of photovoltaic system is to convert solar energy into electrical energy directly. For photovoltaic system tracking maximum power point is important. There are so many MPPT techniques developed and implemented such as fractional open circuit voltage, fractional short circuit current, hill climing,perturb and observe,incremental conductance, fuzzy logic control, neural network,OCC MPPT,slide mode control etc. Among these fractional open circuit and fractional short circuit extract maximum power easily and effectively but require periodical measurement of voltage and current along with power loss. P&O and hill climing are continuously used as their increased efficiency and simple in implementation but for sudden change in solar radiations these algorithms are drift away from MPP.fuzzy logic and sliding mode are rarely used because there difficult design and necessity of costly digital processor.To overcome this problem this method employs high efficiency.several techniques of MPPT'S are discussed in this paper out of which proposed method has several advantages over other conventional MPPT methods.The proposed Adaptive technique is discussed in detail with SEPIC converter which helps to maintain maximum power at load.

II. MPPT TECHNIQUES

1.The Modified Adaptive Hill Climbing Mppt Method:-

A modified adaptive hill climbing (MAHC) MPPT control method is introduced,

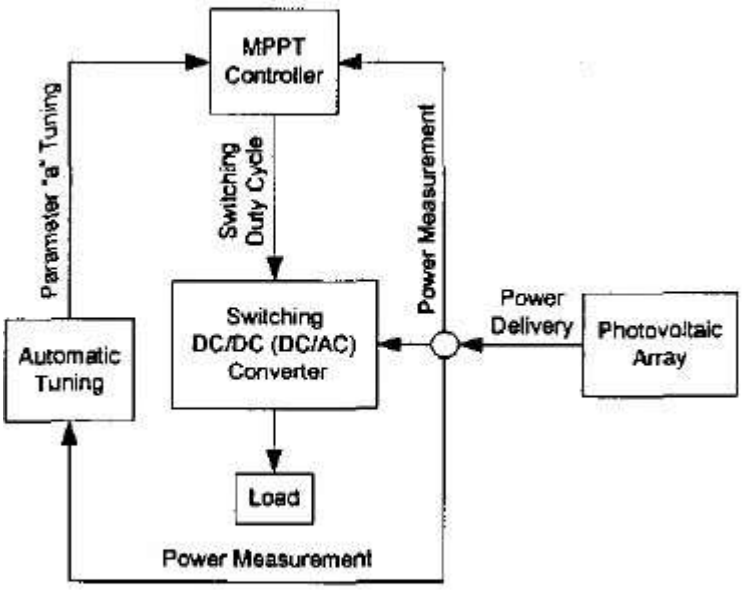

Fig1:The control structure with automatic parameter tunning

In the design, the automatic tuning topology was illustrated as a linear equation:

$$a(k) = \frac{M|\Delta P|}{a(k-1)}$$

where $\Delta P = P(k) - P(k-1)$ represents change of power condition.
During the transient stage ,when the power varies in a more range primarily due to sudden environmental change, then to satisfy the quick response this tuner will change the “a” to a large value.. When the power variation is less, the controller considers that the system enters the steady-state stage and the value of "a" becomes small for smooth control signal.
This is tuning mechanism, in the controller design both dynamic and steady-state requirements can be considered, because the critical parameter is updated and adjustment adaptively.
The variations from the local optimal operating point can be detected by the Modified Adaptive Hill Climing controller and to re-capture the new maximum power points at the two different insolation levels the control variables can be adjusted.
The automatic parameter tuning was carrying out to satisfy the requirements of good dynamic and steady-state performances.

2.The Perturb and observed method with buck boost converter:-

MPPT technique (Perturb and Observe (P&O) method, Buck- Boost DC-DC converters will discussed

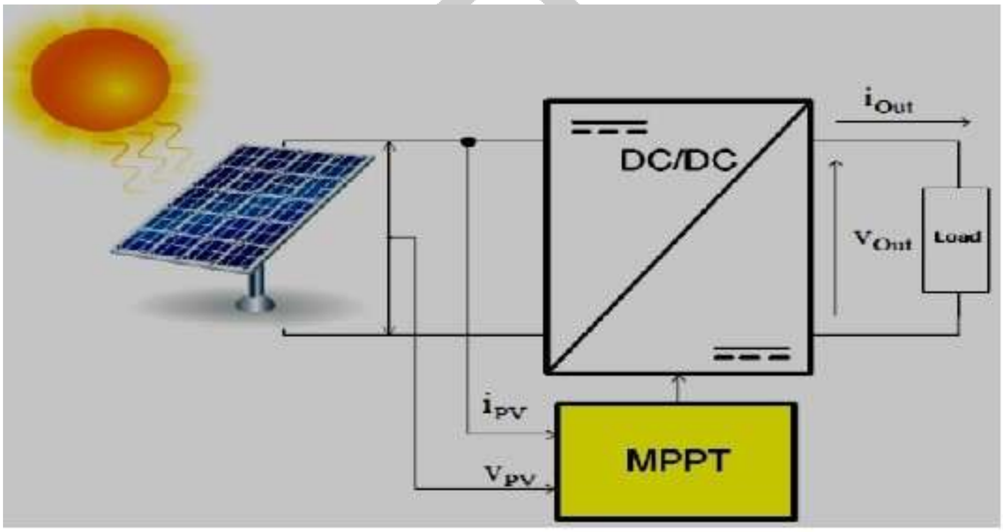

Fig 2. PV module and dc/ dc converter with MPPT

In this approach, perturbation given to the module voltage periodically and the corresponding output power is compared with at the previous perturbing cycle .A slight perturbation is introduce in this system. This causes various power of the solar module.
If the power increases due to the perturbation then the perturbation is in the same direction continued. After the maximum power is reached the power at the MPP is zero and after that instant decreases and hence the perturbation is reverses.
When the condition is stable the algorithm oscillates around the peak power point. To maintain the power variation small the perturbation size is remain very small.
The technique is advanced due to it sets a reference voltage of the module corresponding to the maximum voltage of the module. After that PI controller transfer the operating point of the module to that particular voltage level. Due to this perturbation some power loss is observed, also it fails to track the peak power under fast changing atmospheric conditions.
A non isolated DC-DC converter (step up/ step down) is used to convert the maximum power to the load.
This method is slow to find the peak power point if the voltage is away from maximum power point.

3.Incremental conductance method:-

The oscillation of perturb around maximum power point of the perturb and observe method to track the maximum power under sudden change in atmospheric condition is overcome by IC method. The Incremental Conductance can determine that the MPPT has reached the Peak Power Point and stop perturbing the operating point.

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

If this condition is not met, the direction in which the MPPT operating point must be perturbed can be evaluated using the relationship between $\frac{dI}{dV}$ and $-\frac{I}{V}$. This relationship is derived from the truth that $\frac{dP}{dV}$ is negative when the MPPT is on the right side curve of the Peak Power point and positive when it is on the left side curve of the MPP.

$$\frac{\Delta I}{\Delta V} = \frac{-I}{V} \qquad \text{at MPP}$$

$$\frac{\Delta I}{\Delta V} > \frac{-I}{V} \qquad \text{at left of MPP}$$

$$\frac{\Delta I}{\Delta V} < \frac{-I}{V} \qquad \text{at right of MPP}$$

By using this method we can determine, the MPPT has reached the MPP, where P&O oscillates around the MPP this is advantage over P&O. Also, rapidly increasing and decreasing irradiance conditions with higher precision than perturb and observe can be tracked by incremental conductance method. The disadvantage of this algorithm is the increased complexity.

4.Fuzzy logic control

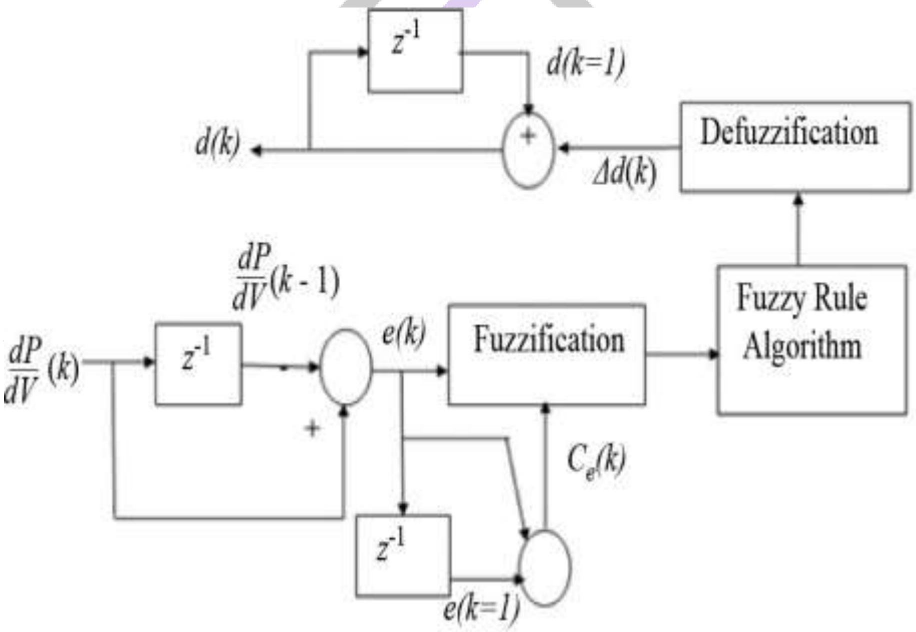

Fig3-Block diagram of fuzzy logic MPPT technique

Fuzzy Logic Based MPPT Technique: FL control implements in three steps as Fuzzzification,decision making,defuzziication. During fuzzification crisp input variables are converted into linguistic variables which are based on membership function. In decision making, it defines controller behavior. And in the last step output is converted into numerical variable.

FL-based MPPT do not require the knowledge of the exact PV model. The Fuzzy Logic-based MPPT has two inputs and one output. The two input variables are error (e) and change in error at the k_{th} sampled time are defined as follows:

$$e(k) = \frac{dP}{dV}(k) - \frac{dP}{dV}(k-1)$$

$$C_e(k) = e(k) - e(k-1)$$

Where $e(k)$ implies if the error of position of operating point of load at the k_{th} instant, while $C_e(k)$ expresses the moving direction of this point.
Although it has improved performance but it is not commonly used due to it is complex structure and require expensive digital processor.

5.Proposed Adaptive voltage sensor based MPPT technique:-

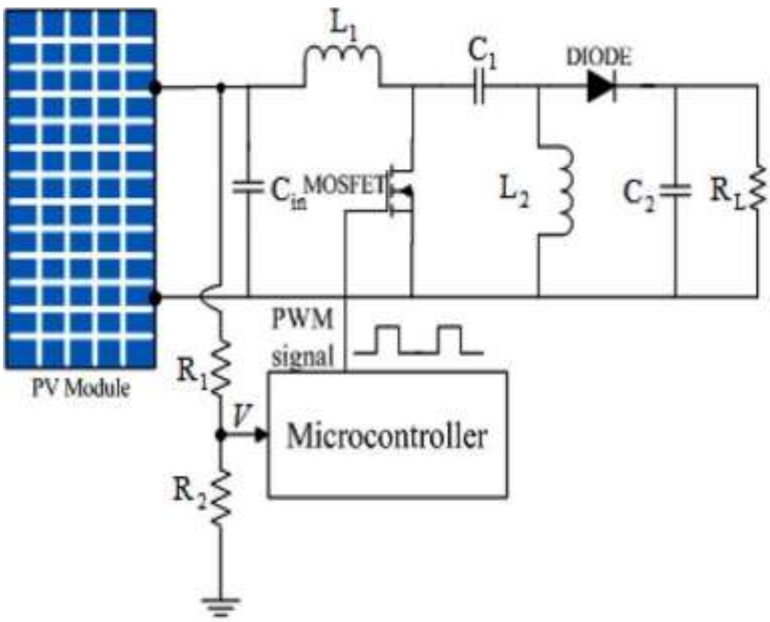

Fig4:-A Circuit model of proposed PV System

For maximum power extraction MPPT controller is important. If load is already connected to the PV array then impedance mismatch is their so it is not possible to operate at peak power point. The converter used to operate at Peak power point by changing the duty cycle generated from MPPT controller.
Current sensor has some disadvantage; therefore voltage sensor is better compare with current sensor with low power loss as well as cost. The MPPT which can sense voltage and with fixed size is implemented and verified for an interleaved dual boost converter. By considering an objective function an adaptive voltage sensor based MPPT with a constant start up scaling factor has been developed.
To obtain fast tracking response and reduced steady state oscillation a variable scaling factor is used in the proposed MPPT technique. The main concern of MPPT technique are steady state behavior and drift phenomenon used to determine the tracking efficiency. In this adaptive technique, steady state behavior and drift analysis for the voltage sensor based MPPT method have been implemented. To increase the range of operation of Photovoltaic voltage we used single ended primary inductance converter (SEPIC).Non-inverting output polarity, it has easy to operate and has low input current ripple has an advantages of this converter. The main factor is perturbation time and perturbation step size in any MPPT algorithm. The selection criterions for these two parameters are as follows:
Choosing proper perturbation – Due to step change in duty cycle, the perturbation time should be greater than the setting time of the system. If the setting time is different, the Duty cycle values will be different. For a maximum step, change in duty cycle which results in perturbation time greater than setting time.
Choosing proper perturbation step size – Considering dynamic and steady state performance the perturbation step size should be selected. The dynamic performance can be improved by using maximum value of step size and the steady state performance will be improved by smaller value which results in lower oscillation around the MPP.
We design the iterative values of PV voltage and duty cycle of the converter as VPV (K), VPV (K - 1), D (K) and D (K - 1) respectively. The iteration values of voltage and duty cycle are

$$dV_{PV} = V_{PV}(k) - V_{PV}(k-1)$$

$$dD = D(k) - D(k-1)$$

Change of objective function Q decide the operating point and the duty cycle is increased or decreased by ΔD as mentioned in equation. By using sign of Q as positive then it is incremented and if Q is negative then duty cycle is decremented by ΔD. Moreover the duty cycle is changed by adjusting the D value. Thus

$$D(k+1) = D(k) \pm \Delta D$$

We cannot satisfy the requirement of MPPT controller in different conditions by using the fixed scaling factor so the proposed algorithm uses two different scaling factors M1 and M2 to optimally vary the perturbation step size ΔD, which is linear function of Q by

$$\Delta D = M_i Q$$

The scaling factor Mi (I = 1, 2) plays a vital role in an adaptive MPPT method; therefore it should be selected to increase the peak power tracking efficiency. Both M1 and M2 are used to reduce the tracking time and power loss in the steady state. This proposed method enhances system performance in terms of transient and steady state.
Drift means movement of the operating point in opposite direction for a change in insolation. The drift analysis can be examined by calculating the change in operating point voltage and the objective function Q for a change in insolation.
the voltage-sensor-based MPPT method is free from drift in case of increase in insolation as well as for a decrease in insolation.

III. Conclusion

A review of several MPPT techniques has been presented in this paper. The proposed Adaptive voltage sensor technique with SEPIC converter has been designed and functionality of MPPT control has been improved. The proposed method has steady state two level operation and drift free phenomenon. The proposed system improves the PV system efficiency and reduces the loss of power in steady state. From this it is noticed that with good designed system,with proper converter and with efficient MPPT algorithm tracking of maximum power can be obtained with less complexity and reduced cost.

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