A REVIEW ON MPPT TECHNIQUES FOR GRID CONNECTED PV SYSTEMS

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Abstract: In this paper brief review the most commonly used MPPT methods has been done for grid connected systems. Also, the paper provides a survey of different modelling parameters required for grid connected systems, such as photovoltaic cell, dc to dc converter, etc. In this paper various design strategies for grid connected PV systems with MPPT has been surveyed & a design for new grid connected PV systems with MPPT is proposed.

Keywords: Maximum Power Point Tracking (MPPT), Perturb & Observe algorithm (P&O), Incremental Conductance(IC), Fuzzy logic, Photovoltaic (PV).

I. INTRODUCTION

With the advancement of technology and demand of energy, the fossil fuels are decreasing exponentially and hence the utilization of renewable energy is required. Solar energy is suitable renewable energy but the continuously changing weather conditions and low efficiency builds the challenges. To obtain the PV's maximum power irrespective of the weather conditions, a maximum power tacking system is required to extract the maximum power fom the solar PV system [1].

The mathematical modeling of PV system had been done [2,3] and observed that due to variation of atmospheric temperature and irradiation level, the operating voltage and current varies and hence power varies. MPPT techniques are required to obtain maximum power The most common maximum power tacking techniques include perturb and observe, hill climbing, incremental conductance under different types of converters. No algorithm can be claimed best as they may vary with respect to simplicity, cost effectiveness, speed of convergence, implementation etc [4- 8].

Perturb and Observe algorithm operates on the change in output power with change in voltage. The tacking system continuously increment or decrement the duty ratio. The voltage is perturbed and change in voltage with respect to change in power is observed. The step size for perturbation is fixed and provided by external source [8- 11]. Inherent ripples present due to power electronic converter system.

II. PHOTOVOLTAIC SYSTEM ELEMENTS

An equivalent system can be seen as given in fig.2.

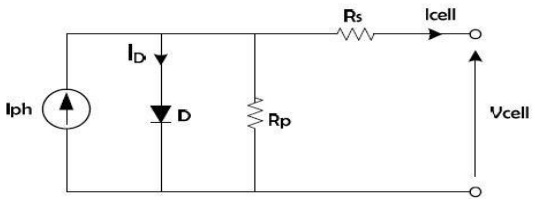

Fig 1: Equivalent Circuit

Diode which represents dark current.

$$I = I_{ph} - Ir\left[e^{\frac{q(V+IRs)}{nkT}} - 1\right] - \frac{V+IR_s}{R_p} \qquad (1)$$

Where: I_{ph} is the photoelectric current
I_s is the cell saturation dark current?
T_c is 10 -19 the cell working temperature
A is ideal factor
R_{sh} is the shunt resistance
R_s is the series resistance

The photo electric current mainly depends on solar isolation & cell's normal working temperature on a particular area which is related by

$$I\text{ph} = [I_{sc} + k_1(T_c - T_{ref})]H \qquad (2)$$

$$I\text{S} = I\text{RS}\left(\frac{T_c}{T_{ref}}\right)^3 e\left[\left(\frac{qE_g(T_c - T_{ref})}{T_{ref}T_c K A}\right)\right] \qquad (3)$$

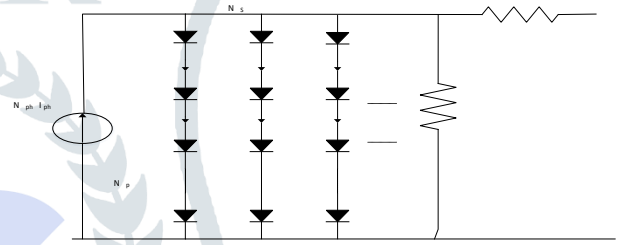

Fig 2: Equivalent Circuit of a number of solar cells in series & parallel

$$I = N_p I_{ph} - N_p I_s \left[e^{\frac{q\left(\frac{V}{N_s} + \frac{IR_s}{N_p}\right)}{kTcA}} - 1\right] - \frac{N_p V/N_s + IR_s}{R_{sh}} \qquad (4)$$

A typical PV IV characteristic of a solar cell is shown in figure based on varying solar irradiation & temperature changes. A solar cell is modelled based on the equivalent circuit.

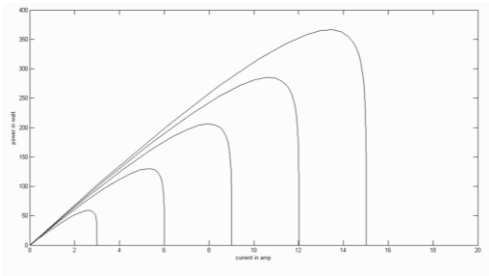

Fig 3: General PV Characteristics

III. BOOST CONVERTER

For a grid connected PV system the 1st stage is the boosting stage in which the i/p voltage from the PV panel is boosted. Generally, a dc-dc converter acts as an link between PV module & load. The MPPT is a load matching problem in which our basic needs are achieved. To vary the i/p resistance of the panel for matching the load resistance (by variations in the duty cycle) which is tracking the max. power, a DC to DC converter is basically needed. Due to more

flexibility, better performance & ease of implementation a boost converter is generally used for PV grid connected systems. In the case of a buck converter the current is not flowing constantly & it is continuously varying. Compared to other type of converters boost converter which provides maximum efficiency.

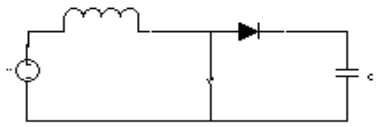

Fig. 4: Boost Converter

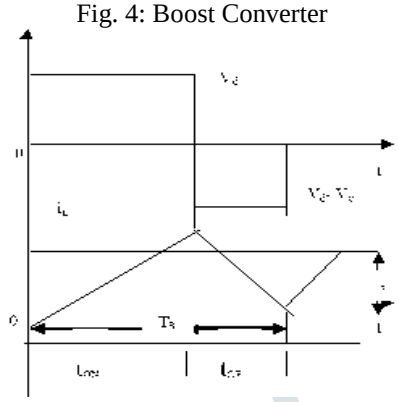

Fig.5 : Waveform

$$Vd * Ton + (Vd - Vo)\, Toff = 0$$
$$Vd * Ton + Vd\, Toff - Vo\, Toff = 0$$
$$Vd\,(Ton + Toff) - Vo\, Toff = 0$$
$$VdT = Vo\, Toff$$
$$Vo/Vd = T/Toff$$
$$Vo/Vd = 1/1 - D$$

Where D is the duty ratio

IV. DC-DC BOOST CONVERTER

To tack the maximum power fom the solar panel, boost converter can be used as the power electronic interface between the solar panel and load. The boost converter enhances the input voltage according to the duty ratio provided by the MPPT controller. The input voltage and output voltage are related by:

$$V_{out} = \frac{V_{in}}{1\text{-}D}$$

Where, Vout is the output voltage of the boost converter, Yin is the input voltage of the boost converter which is the same as the output voltage of solar panel, D is the duty ratio provided by the MPPT controller.

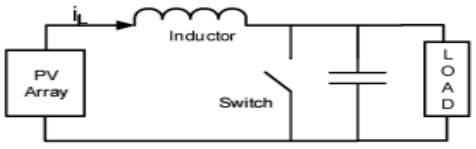

Fig. 6: PV Array Connected Boost Converter

V. VARIOUS MPPT TECHNIQUES

Among various available the most commonly used MPPT algorithms are:

1. Perturb & Observe algorithm
2. Incremental conductance algorithm
3. Fuzzy logic method

A. PERTURB & OBSERVE METHOD

Perturb & Observe (P&O) is the best scheme which is most widely used for max. output. In this scheme only one sensor is used, which is a voltage type sensor, to sense the PV module voltage & therefore the cost came down to very less & therefore less complexity in designing [3]. Also, the time complexity of this scheme's algorithmic design is very less for calculating the max. power but on approaching very near to the Maximum Power Point (MPP) it does not stop at the MPP & keeps on perturbing bidirectional so for that reason it have multiple local max. at the very same point. Start the algorithm which reads the value of the current & voltage from the photovoltaic module from that power is calculated the value of voltage & power at that instant is stored.

Basic MPPT algorithm consists of perturb and observe algorithm the change in power is continuously observed with respect to change in voltage. Initially the operated voltage is incremented and hence compared to its previous value and then observed whether power is incremented or not. If the power is also incremented then the positive perturbation is provided and voltage is again increased until power starts decreasing but if increase in voltage results in decrease in power compared to previous one, then the perturbation direction is reversed. The perturbation is provided externally to the MPPT. Large perturbation step size results in large oscillation whereas small perturbation would result slower rate of convergence.

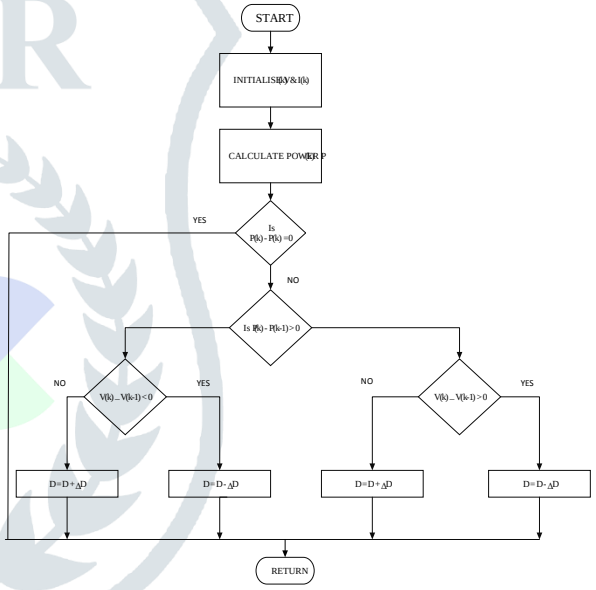

Fig 7: Flow Chart P&O

B. IMPROVED P & O METHOD

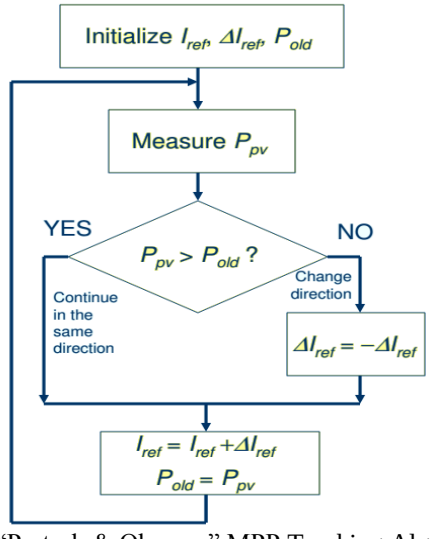

Fig. 8: "Perturb & Observe" MPP Tracking Algorithm

C. INCREMENTAL CONDUCTANCE METHOD

Incremental conductance method generally uses voltage & current sensors to detect the output voltage & current of the PV array hence the complexity of the algorithm increases.

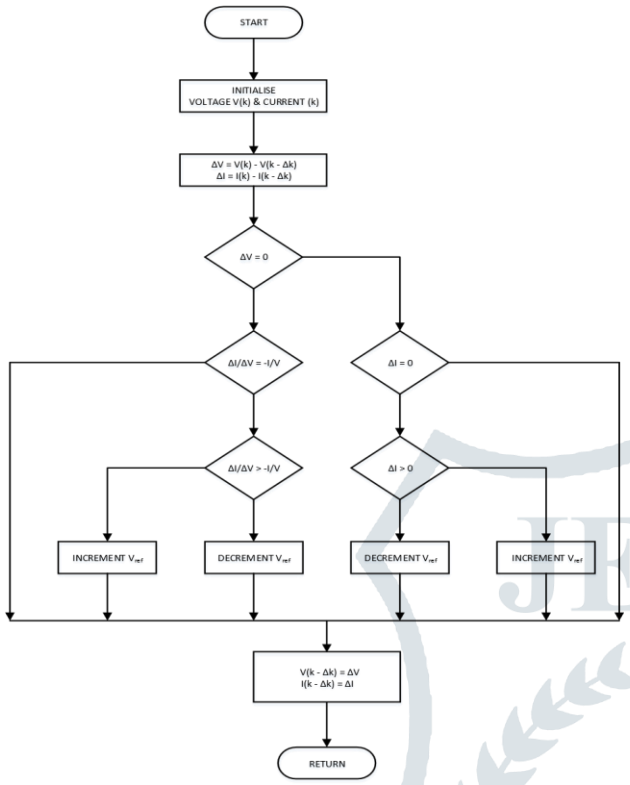

Fig 9: Flow Chart Incremental Conductance

D. FUZZY LOGIC METHOD

Fuzzy logic control algorithm is one of the most popular control algorithm methods which is known by its multimode based variable control algorithm. Fuzzy logic control algorithm is Photovoltaic array dependent. This algorithm is based [7] on the operators experience because this algorithm is followed by certain rules that are given by the operator.

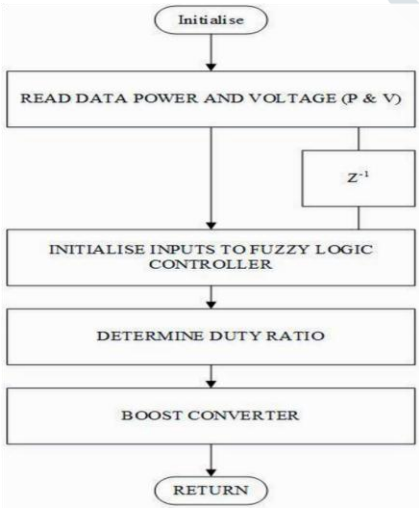

Fig 10: Flow Chart Fuzzy Logic

VI. DOMESTIC GRID CONNECTED SYSTEM

Recently grid connected photovoltaic system have been spreading in residential areas & in industrial areas. So we have to find a suitable MPPT technique that gives a better power output when connected is to find out. Grid interface inverters which transfers the energy from the photovoltaic module to the grid by just keeping the dc link voltage which is to be maintained constant. For a grid connected system the utility network mainly demands for better power quality & power output. In the case of voltage fluctuations control of grid parameters is very difficult. So for a PV system that is connected to a grid first stage is the boosting stage & the second stage is DC-AC converter. An output filter is usually employed which reduces the ripple components due to switching problems.

The proposed work is the design of a domestic PV system for grid connection facility. Performance of the proposed P&O MPPT system will be analyzed by following parameters:

- I-V and P-V Characteristics of PV array.
- Steady state analysis of PV array.
- Dynamic response of PV array assisted by P&O system.

VII. CONCLUSION

Various MPPT techniques for grid connected PV systems have been surveyed for proposing an improved scheme. For a grid connected PV MPPT algorithm plays a major role. A most suitable MPPT technique is chosen based on the implementation cost, number of sensors required, complexity. So for residential & industrial purposes P & O Algorithm performs better results & finds wider applications in grid connected PV systems. In this paper, P&O MPPT technique is focused to extract the maximum power from the solar panel. The tansient and steady state analysis will be carried out for both the techniques and summary of this survey can be concluded as:

- Increase in irradiation level would result in increase in operating current, consequently maximum power increases and decrease in irradiation level would result in decrease in operating current, consequently maximum power decreases.
- Increase in temperature would result in decrease in operating voltage consequently maximum power decreases and decrease in temperature would result in increases in operating voltage consequently maximum power increases.

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