Simulation and Analysis of Grid Connected Photovoltaic System

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***Abstract*— In this paper a different approach for evaluating the performance of Photovoltaic Array is presented and gridconnected DC-AC converter control topology is implemented. Photovoltaic panel is the system which converts solar radiant energy into electrical energy by connecting the solar cell in series and parallel fashion. That converted energy is not constant during the whole day because of change in temperature and irradiance because of climate change and other environmental factors. To avoiding this problem MPPT technique is used which tracks the maximum power point to generate maximum power from the array input. A number of algorithms have been developed for extracting maximum power. This paper details P&O and INC algorithm techniques. And it can be experimentally verified by modeling the PV system with MPPT algorithm in MATLAB Software An extensive simulation study is carried out to validate the proposed control approach.**

***IndexTerms*— Photovoltaic Array, Boost Converter, MPPT, Inverter, Simulation,**

I. INTRODUCTION

The world's conventional sources of energy are diminishing fast, with corresponding rise in cost. Also, the very large use of conventional fossile fuels which are the primary source of energy causes the serious environmental pollution and problems. Therefore renewable energy offers a promising alternative source and has received great attention in research because it appears to be one of the possible solutions to environmental problem. Also, one of the most promising applications of renewable energy to supply power for remote communities where main electrical grid is absent. There are many renewable energy sources are available. Photovoltaic generation is becoming increasingly important as a renewable energy source since it exhibits a great merits such a less maintenance, noise free and pollution free. PV systems use solar panel to convert sunlight into electricity and provide energy to the consumers moreover feeds power into the grid [1].

Due to large amount of combustion of fossil fuels for generating electricity, the quantity green house gases in atmosphere is increases up to 17% from year 2004-2014. Oil reserves would have been exhausted by 2040, natural gas by 2060, and coal by 2300. There are two ways such as solar tracking system and Maximum Power Point Tracking (MPPT). In the survey, the maximum energy extracted from the sun without MPPT is only about 30-40 %. The state of the art techniques to track the maximum available output power of PV systems are called the maximum-power point tracking (MPPT). There are many techniques have been developed to implement MPPT, these techniques are different in their efficiency, speed, hardware implementation, cost, popularity. In this paper only two techniques are studied and results of that algorithm are observed which are P&O and INC.

II. PROPOSED TOPOLOGY

The proposed topology consists of control strategy of interconnection between photovoltaic panel with dc/dc converter and grid connected inverter [3] as shown in fig 1.

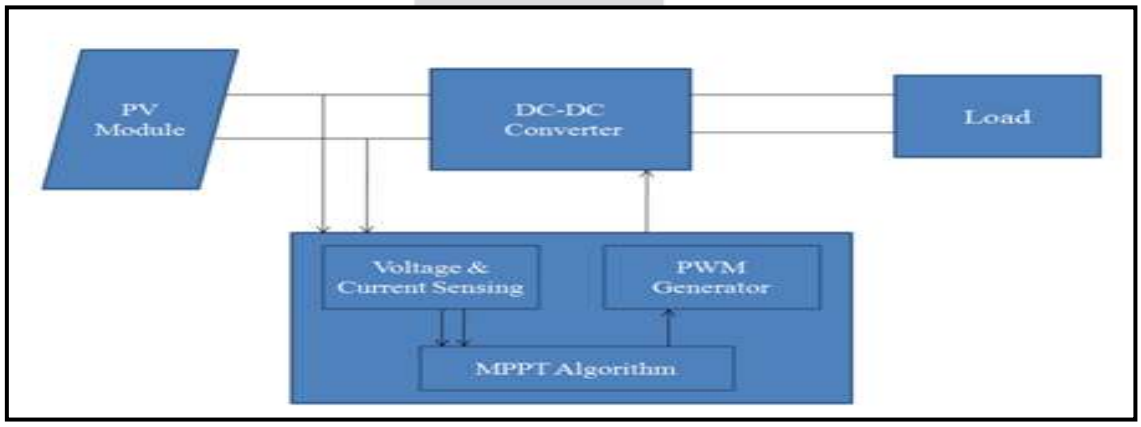

Fig 1: Grid Connected PV System

The solar energy is widely used in the generation of non conventional power but that generating capacity of solar cell with respect to incident power on that cell is very less. The energy potential of the sun is immense, but despite this unlimited solar energy resource, harvesting it is a challenge mainly because of the limited efficiency of the array cells. The best conversion efficiency of most commercially available solar cells is in the range 10-20s%. The characteristics of a solar cell show that when power is plotted against voltage there is a voltage value corresponding to the MPP and normally this point is a function of the solar light level. Solar energy can be a standalone generating unit or can be a grid connected generating unit. If we have to satisfy our load demand we should have to synchronize our system with grid. Before synchronization our generation should be constant and for getting that constant power maximum power point tracking system should be used. Which will gives us the maximum power of rated capacity of the solar cell. The generated power will synchronize with the grid so that the load requirement should satisfy. And whenever our generated power is more than that should supply to grid.. This proposed topology is simulated in MATLAB/SIMULINK environment which shows that output current and voltage of the inverter have the same phase as that of grid voltage.

III. SYSTEM MODEL

A. Photovoltaic array

A sunlight based cell is the key working unit of a daylight based board. A photovoltaic display is surrounded by making a relationship of various PV cells in course of action and parallel. Considering simply a lone PV cell; it could be shown by using a current source, a diode and resistors. This model is the single diode model of PV cell. Two diode models are similarly used however simply single diode model is considered.

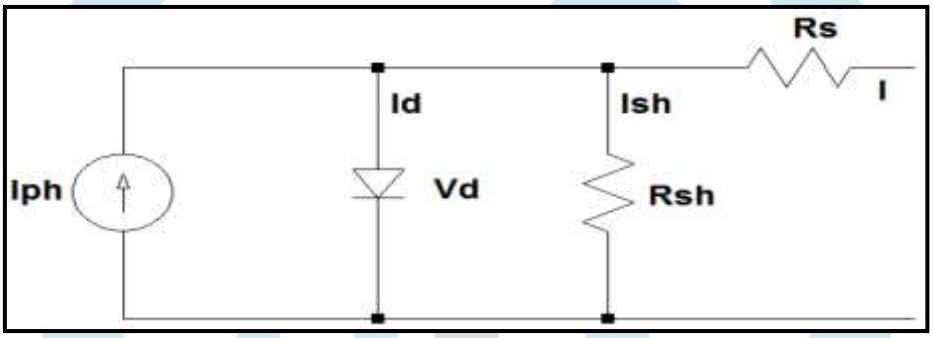

Fig 2: Model of a Solar Cell

The characteristic equation for a photovoltaic cell is given by,

$Iph = Iscr + ki(T - 298)*\eta$
k:Boltzmann's constant, 1.38 *10-23 J/K;
q: Electron charge, 1.6*10-19 C;
Ki: Short circuit current temperature coefficient at Iscr

The trademark articulation of a PV module relies on number of cells in parallel and number of cells in series in the arrangement. It is inspected from comes about that the variety in present is not as much subject to the parallel resistance and is reliant on the series resistance [2] I-V and P-V curves for a solar cell are shown in the following figure. It can be seen that the cell operates as a constant current source at lesser values of operating voltages and a constant voltage source at lesser values of input current.

B. Control Strategy

The complete control strategy is explained in below block diagram.

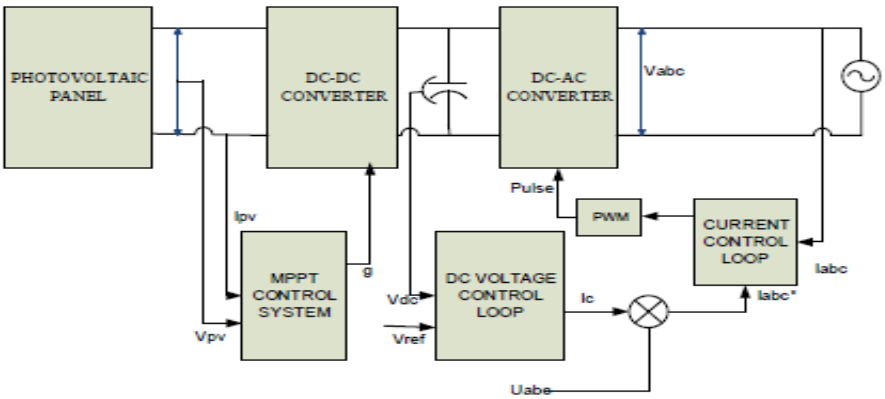

Fig 3. Block diagram of MPPT control scheme

It is clear from the fig 3 that MPPT receive the PV voltage and current and generate reference voltage (V_{ref}) and this Vref coming from the MPPT (maximum power point tracker) is fed to the PWM which give the gate control signal to the DC-DC converter. Another topology is inverter control which contains outer dc voltage control loop and inner current control loop. This control loop is forced to maintain the input dc voltage of dc-ac converter to constant. The dc power is then converted into ac power before transported to utility grid.

C. P&O Control Strategy of MPPT

To design the P&O technique in MATLAB software, input suply is given from solar cell. The two source current and voltage are the input of MPPT from solar cell. In Perturb and observe (P&O), the MPPT algorithm is based on the calculation of the PV Power and the power change by sampling both the PV current and voltage. The tracker operates by periodically incrementing or decrementing the solar array voltage. The algorithm works when instantaneous PV array voltage and current are used, as long as sampling occurs only once in each switching cycle. The process is repeated periodically until the MPP is reached. The system then oscillates about the MPP. The oscillation can be minimized by reducing the perturbation step size. However, a smaller perturbation size slows down the MPPT equations.

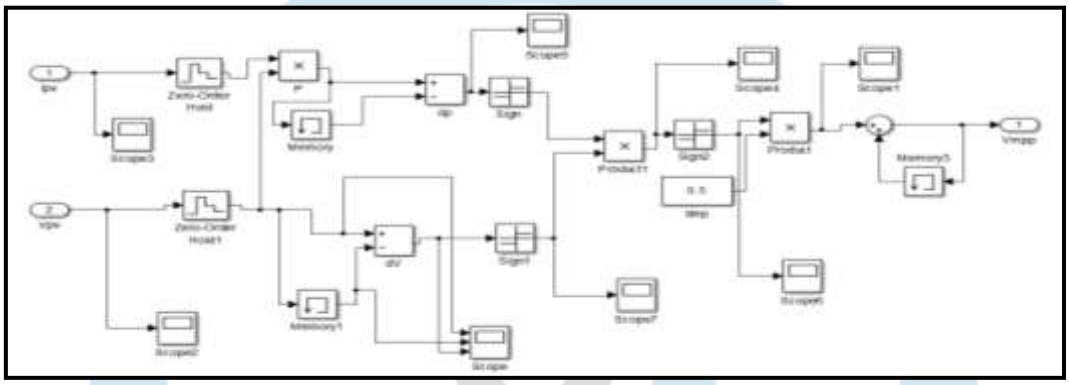

Fig 4 : Simulation of Perturb and Observe Technique

D. INC Control Strategy of MPPT

Output voltage and current of the PV array is the input of module, and a derivative module is used in this module which is different from the MPPT module of P&O.

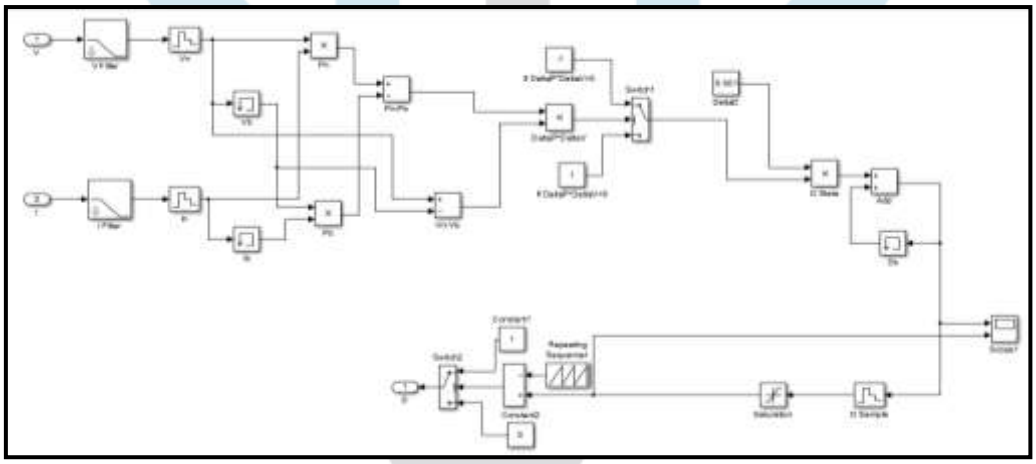

Fig 5: Simulation of Incremental Conductance Technique

E. Control Strategy of Grid Connected Inverter

This paper propose the current control approach based on hysteresis comparator [8] where reference current is the control variable. This reference current (Iabc*) is calculated by multiplication of in-phase component of reference current(Ic) to the unity grid voltage component (Uabc). Also, Ic current is calculated from the dc-voltage control loop as shown in figure 8 by comparing the Vdc to the Vdc*, and then respective error signal is given to the PI controller. This PI controller is responsible to maintain a constant dc – link voltage at the input of the grid interface inverter.

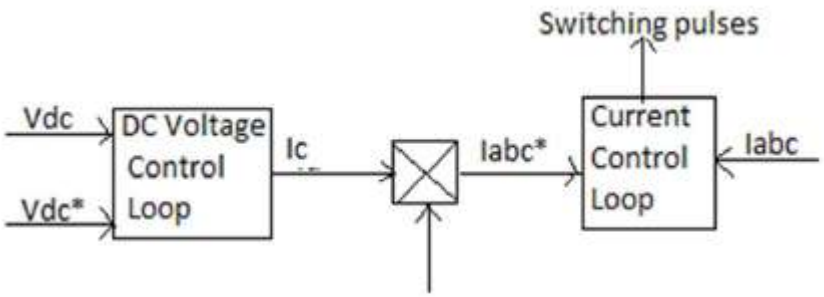

Fig 6 : Control strategy of grid interface inverter

Now, the reference current(Iabc*) are compare with the actual grid current (Iabc) in the current control loop as shown in figure (6) and resulting error signal are given to the hysteresis current controller to generate the switching pulse for the grid interface inverter.

IV. Result

The simulation model of boost converter with MPPT is simulated with the help of block diagram as presented in fig.(5). The proposed work is validated with the help of table(1and 2) having system response for different control strategy is given. The simulation is run for 0.2 sec and insolation is varied in a particular range.

Solar Irradiance W/m^2	MPPT Output Voltage (P&O)				
	25^0 C	30^0 C	35^0 C	40^0 C	45^0 C
600	16.8	16.7	16.6	16.5	16.4
750	16	15.8	15.5	15.2	15.2
1000	13	13	13	12.8	12.7
1250	11	10.5	10.2	10	9.9

Table 1: Output voltage of P&O

Solar Irradiance W/m^2	MPPT Output Voltage (INC)				
	25^0 C	30^0 C	35^0 C	40^0 C	45^0 C
600	8	7.9	8	8	8
750	9.5	9.5	9.5	9.4	9.4
1000	12	11.5	11.5	11.5	11.5
1250	13.5	13.4	13.4	13.4	13.3

Table 2: Output voltage of INC

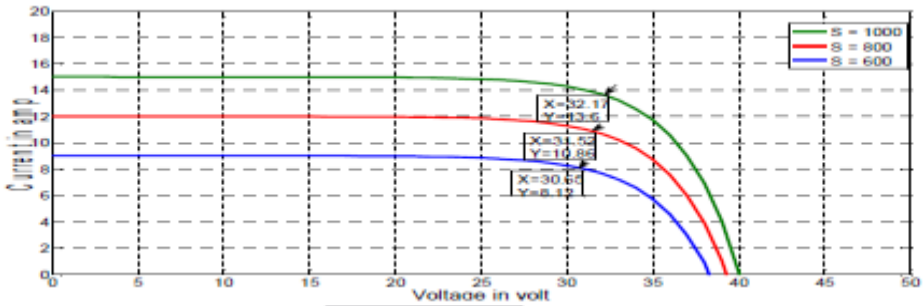

Fig 7: Imp&Vmp points in I-V Curve at different irradiations.

V. Conclusion:

The simulation results of P&O and INC are nearly identical, but results obtained from incremental conductance method are more accurate and precise. The hardware implementation of incremental conductance method is difficult to fabricate due its individual programming so we are preferred to implement the perturb and observe method for tracking MPP. The various values of the voltage and current obtained have been plotted in the IV curves of the PV array at different insulation levels and simulation results of MPPT and grid connected inverter verify the correctness of the proposed model.

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