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Design and Simulink of Intelligent Solar Energy Improvement with PV Module

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Abstract

In this paper, the study treats the case of the conversion of solar energy, which is one part of non-pollutant energy, to electrical one. Here two different methods are used to maximize the generated power. Thus, a comparison between the 'perturb and observe' control method and the 'incremental conductance' control method are given, analysed and discussed for solar panel. The solar panel is modelled and analysed in MATLAB/SIMULINK. The proposed circuit model has several advantages: simple, reliable, allows simulation of basic cells, group of cells, or mismatched panels that work under different operating conditions. Starting from the implemented model of the photovoltaic (PV) array together with the buck converter and its MPPT control have been simulated the PV systems with both MPPT algorithms at different solar radiation and temperature. The Solar panel can produce maximum power at a particular operating point called Maximum Power Point (MPP).To produce maximum power and to get maximum efficiency, the entire photovoltaic panel must operate at this particular point. This system is developed by combining the models established of solar PV module and DC-DC Boost converter. The principle of P&O is to create a perturbation by decreasing or increasing the duty cycle of boost converter and then observing the direction of change of PV output. By varying the duty cycle of the buck boost converter, the source impedance can be matched to adjust the load impedance to improve the efficiency of the system. The general topologies, sizing criteria, and control are presented, as well as considerations on efficiency. And finally are presented the simulations result show the effectiveness to produce a more stable power.

Keywords- photovoltaic system, maximum power point tracking(MPPT), perturb and observe, increamental conductance.

1. INTRODUCTION

A renewable energy system convert the energy found in sunlight, water, wind, geothermal heat, or biomass into a form, which we can use in the form of heat or electricity. The majority of the renewable energy comes either directly or indirectly from sun and wind and can never be fatigued, and therefore they are called renewable. These techniques vary in many aspects as: convergence speed, digital or analogical implementation, sensors required, cost, range of effectiveness, and in other aspects. Several mathematical models for computer simulation of PV systems have been built over the past four decades [1].

These models describe the output characteristics in terms of the major governing parameters. The output of the PV systems is affected mainly by the solar insolation, cell temperature, and load voltage [2].Hence the demand for renewable energy sources increases as it is environmental friendly and pollution free which reduces the greenhouse effect. Solar photovoltaic (PV) water pumping has been recognized as suitable for grid-isolated rural locations in poor countries where there are high levels of solar radiation

2. SOLAR ENERGY

In today's climate of growing energy needs and increasing environmental concern, we must have to think for an alternative to the use of non-renewable and polluting fossil fuels. One such alternative is solar energy. Solar energy has a vast area of application such as electricity generation for distribution, heating water, lighting building, crop drying etc. Photovoltaic cells, by their very nature, convert radiation to electricity. Solar power has two big advantages over fossil fuels. The first is in the fact that it is renewable; it is never going to run out. The second is its effect on the environment. Solar panel is the fundamental energy conversion component of photovoltaic (PV) systems. Its conversion efficiency depends on many extrinsic factors, such as insolation levels, temperature, and load condition. There are three major approaches for maximizing power extraction in medium- and large-scale systems. They are sun tracking, maximum power point (MPP) tracking or both. MPP tracking is popular for the small-scale systems based on economic reasons. [3]. Standard test conditions are as follows:

Temperature (T_n) = 25^0C ; Irradiance (G_n) = 1000 W/m^2

3. EQUIVALENT CIRCUIT OF PV MODULE

The electrical behaviour of PV module can be observed using its equivalent circuit. The equivalent circuit of a PV module is as follows :

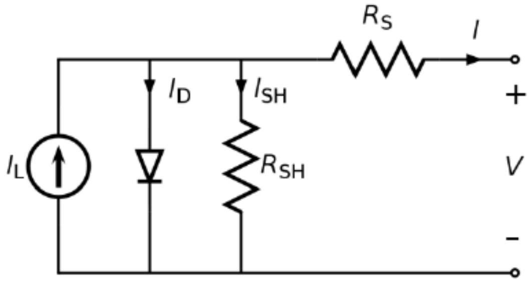

Fig. 1(a) Equivalent circuit of a PV cell

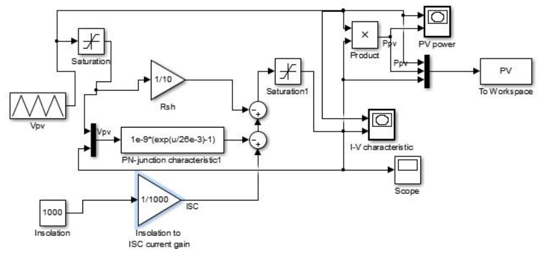

Fig. 1(b) Simulation circuit of a PV module

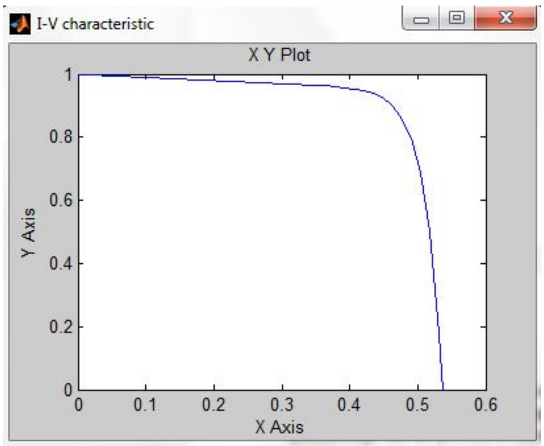

Fig. 2(a) I-V Characteristics

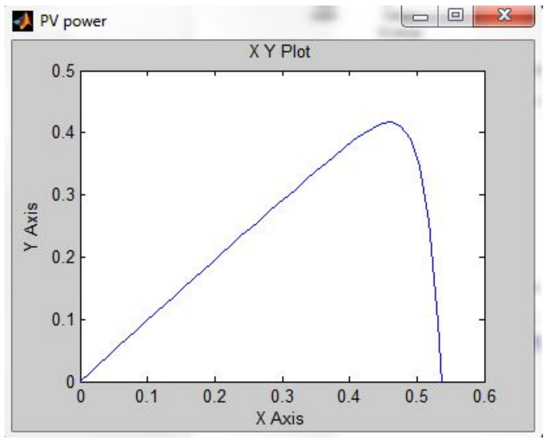

Fig. 2(b) P-V Characteristics

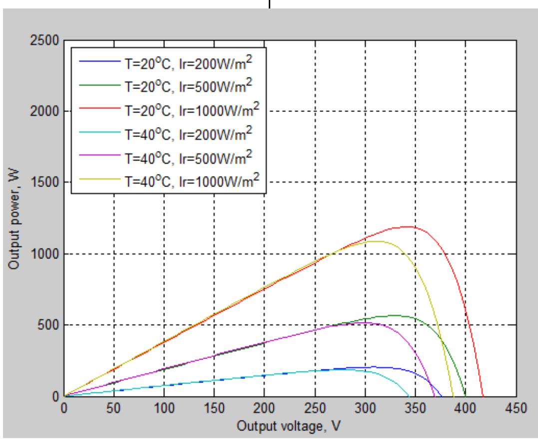

Fig. 2(c) P-V Characteristics at different level of Irradiations

This mathematical approach has been implemented in MATLAB. For MATLAB Simulation Model BP Solar BP SX 150S PV module has been chosen. Module is made of 72 multi- crystalline silicon solar cells in series and 150W of maximum nominal power. The current-voltage (I-V) curve is based on the module being under standard conditions of sunlight (1000w/m^2) and module temperature (25°C). Two main factors affect the performance of solar cells. These are temperature and solar irradiance. The current through diode is given by:

$$ID = I\,[\,\exp\,(q(V + I\,R_S)/KT)) - 1] \quad (1)$$

The solar cell output current:

$$I = IL - ID - I_{sh} \quad (2)$$

$$I = IL - I\,[\,\exp\,(q(V + I\,R_S)/KT)) - 1] - (\,V + IR_S\,)/\,R_{sh} \quad (3)$$

Where: I : Solar cell current (A), I: Light generated current (A) [Short circuit value assuming no series/ shunt resistance];ID: Diode saturation current (A);: Electron charge (1.6×10^{-19} C);K : B : Cell temperature in Kelvin (K) ;V : solar cell output voltage (V); Rs: Solar resistance(Ω) ;Rsh: Solar cell shunt resistance (Ω).

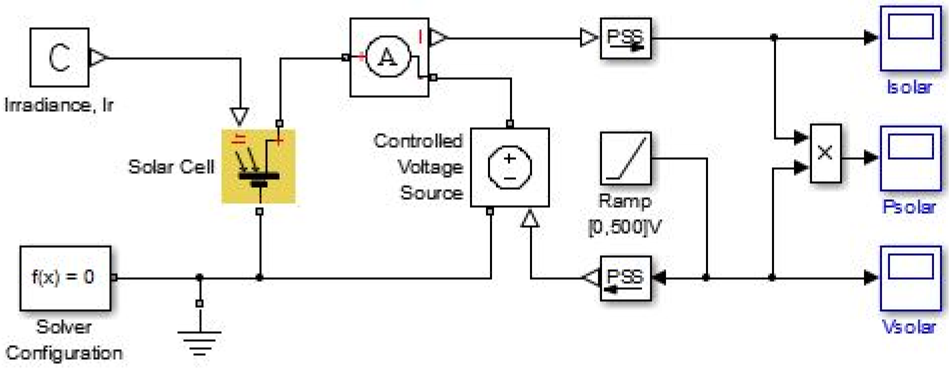

Fig. 3 Simulink Model of Solar Cell

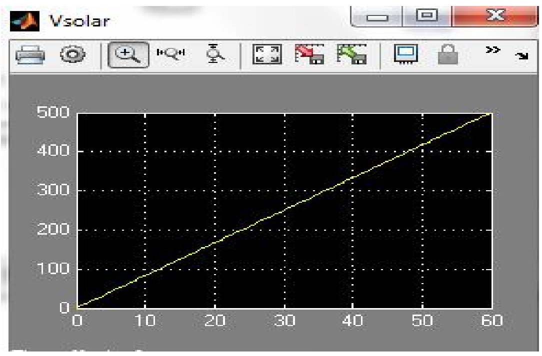

Fig. 4(a) Solar cell Voltage

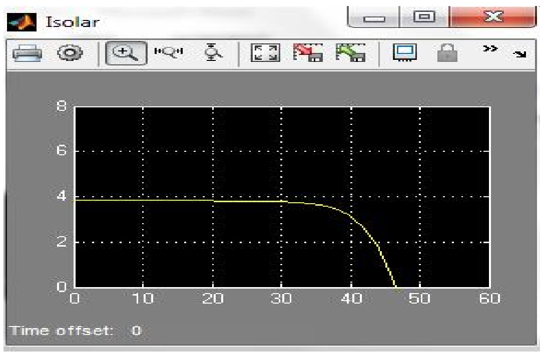

Fig. 4(b) Solar cell Current

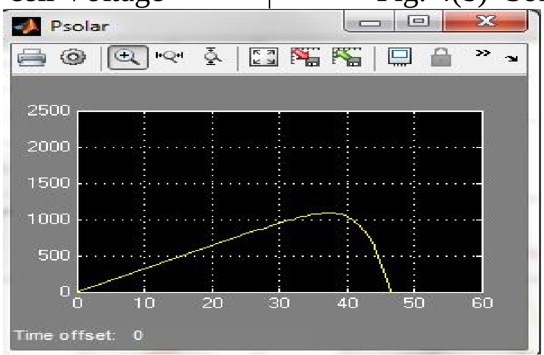

Fig. 4(c) Solar cell Power

4. BUCK BOOST CONVERTER

The boost converter is also known as the step-up converter. The name implies it's typically application of converting a low input-voltage to a high out-put voltage, essentially functioning like a reversed buck converter [4].

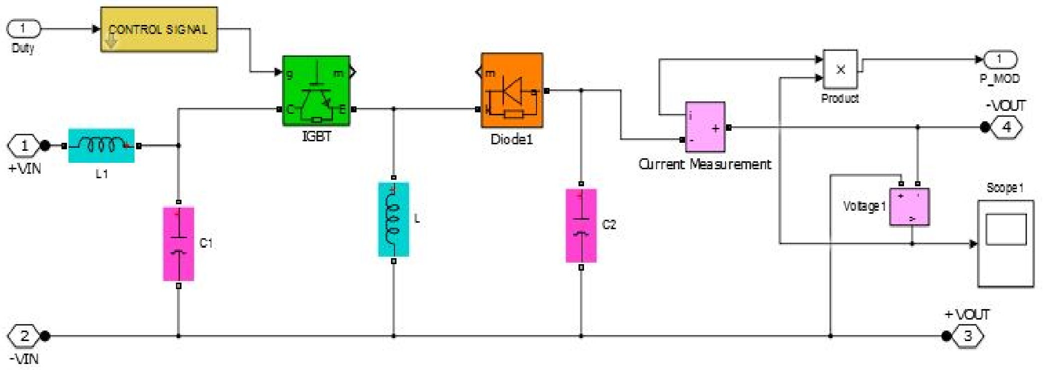

Fig. 5 Simulation circuit of Buck Boost Converter

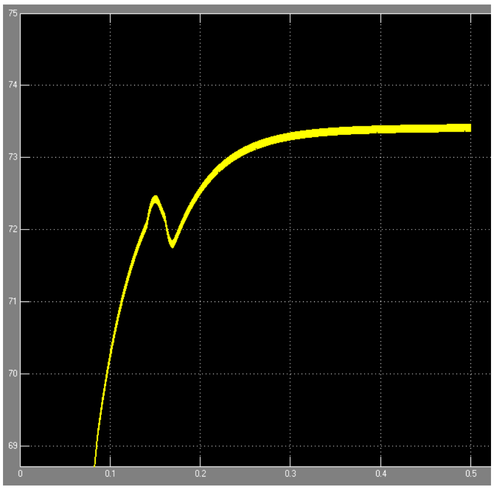

Fig. 6 Simulation result of voltage of Converter

5. MAXIMUM POWER POINT TRACKING

Maximum power point plays an important role in photovoltaic system because they maximize the power output from a PV system for a given set of conditions and therefore maximize the array efficiency. The different methods used to track the maximum power point are:

(i) Perturb and Observe method
(ii) Incremental Conductance method
(iii) Parasitic Capacitance method
(iv) Constant Voltage method

5.1 Perturb and Observation**n:**

In this algorithm a slight perturbation is introduced to the system. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. When the steady state is reached. the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small The algorithm increments or decrements continuously the reference voltage or current based on the previous value of power until reaches the MPP [5, 6]. When dP/dV > 0 and the operating voltage of PV array is perturbed in a specific direction, it known that perturbation moves the operating point. of PV array to the MPP. P&O method will then continue to perturb the PV voltage in the same direction. When dP/dV <0, the perturbation moves the operating point of PV array away from the MPP and the P&O method reverses the direction of the perturbation [7, 8].

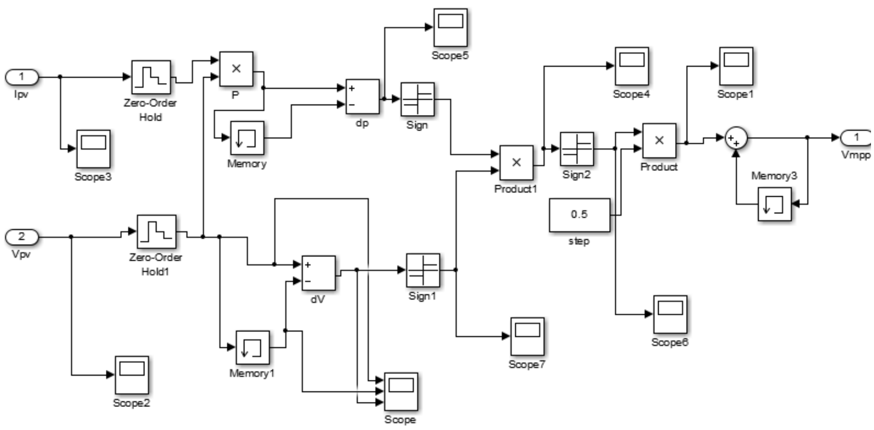

Fig. 7 Simulation Model of Perturb and Observe Method

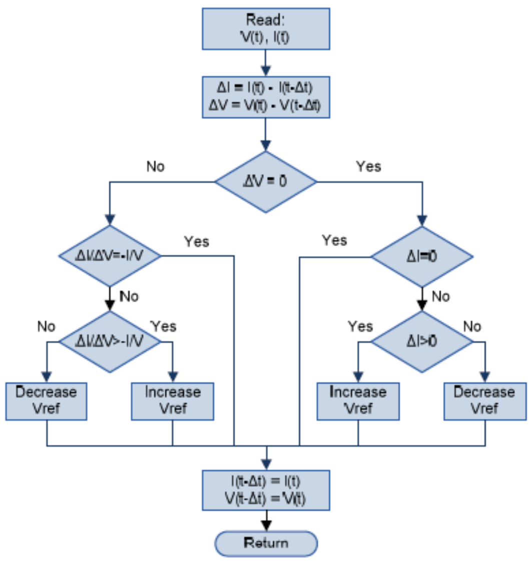

Fig. 8 Algorithm of Perturb and Observe Method

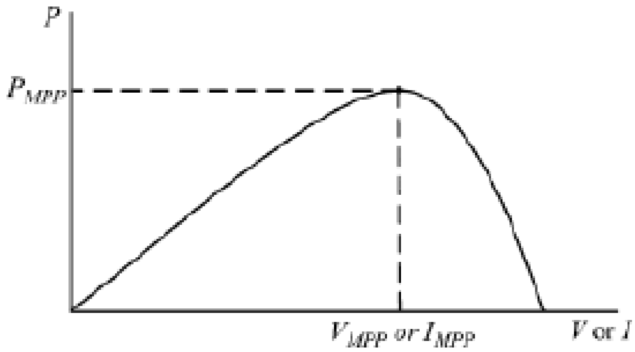

Fig. 9 P-I and P-V Graph s for Perturb & Observe method

5.2 Incremental Conductance Method

In incremental conductance method the array terminal voltage is always adjusted according to the MPP voltage it is based on the incremental and instantaneous conductance of the PV module.The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method. The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than P and O.

The slope of the P-V module power curve is zero at The MPP, increasing on the left of the MPP and decreasing on the Right hand side of the MPP. The basic equations of this method are as follows.

$dP/dV=0$ at MPP (4)

$dP/dV>0$ left of MPP (5)

$dP/dV<0$ right of MPP (6)

$dP/dV = d(VI)/d(V)= I + V*dI/dV$ (7)

The dP/dV is defined as Maximum power point identifier factor. By utilizing this factor, the IC method is proposed to effectively track the MPP of PV array [8]. The following definitions are considered to track the MPP.

$\Delta I/\Delta V = -I/V$ at MPP, $\Delta Vn=0$ (8)

$\Delta I/\Delta V > -I/V$ left of MPP, $\Delta Vn= + \delta$ (9)

$\Delta I/\Delta V < -I/V$ right of MPP, $\Delta Vn= -\delta$ (10)

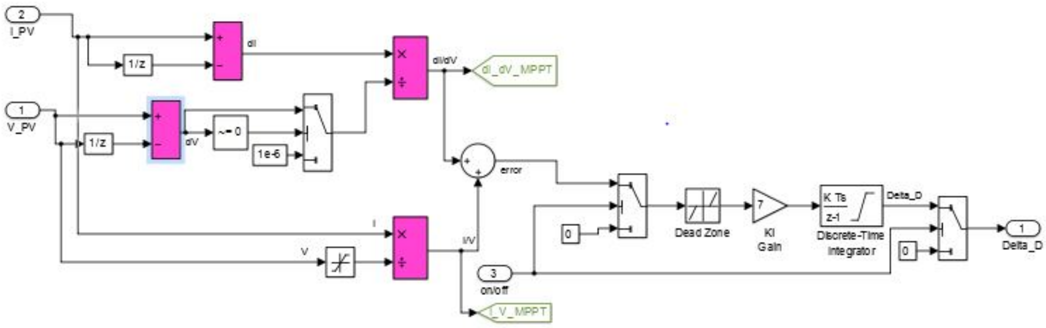

Fig. 10 Simulation Model of Incremental Conductance Method

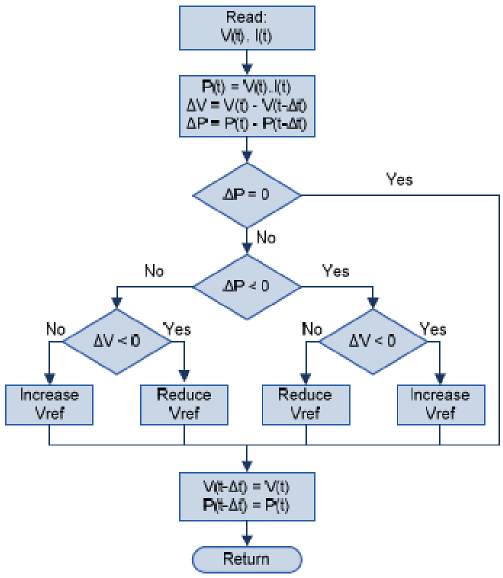

Fig. 11 Algorithm of Incremental Conductance Method

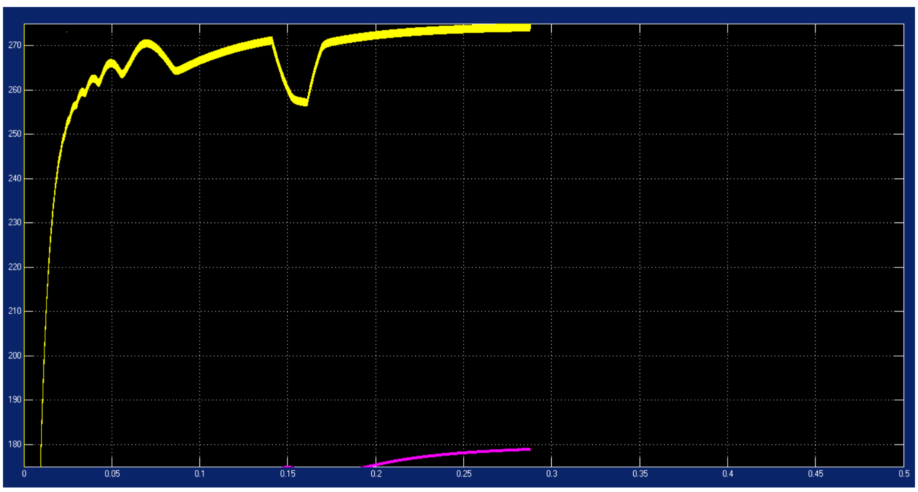

Fig. 12 Current and voltage for output from Solar MPPT Solar panel

6. CONCLUSION

This paper presents a SIMULINK and SimElectronics based model for PV panel. It also included varying irradiation. P&O and incremental conductance methods algorithms have been designed and simulated for the proposed PV system. Comparison of Perturb and Observe method and Incremental Conductance algorithm have been presented for different irradiation conditions.

7. REFERENCES

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