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A Simulink Model of PV Array using P&O Technique for Maximizing the Power

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***Abstract*: -- The following paper is based on simulation of Perturb and Observe (P&O) technique to find the maximum power point of a photovoltaic (PV) cell. The maximum power point tracking algorithm is based on changing either voltage or current. The algorithm works so that the operating point works at maximum power output. The system is designed for the 2KW resistive load with the boost converter to get the desired dc output voltage. The filters are used to minimize the ripple at dc side. Standard test condition for irradiance and temperature is considered which is 1000 W/m2 and 25o C.**

***Keywords:* - Photovoltaic, MPPT, P&O, Boost Converter, VRF.**

I. INTRODUCTION

As world worried with exhaustion of conventional fuel and the environmental problems due to conventional energy production technique, renewable source of energy like solar power, wind power, ocean wave, geothermal energy etc. are in great demand. But we need huge amount of energy to meet the large population. So solar is the only source of energy that can fulfil the demand [1]. PV cells are used to collect the solar power and having no noise, pollution and other environmental issues. PV array has so many applications like water pumping system, electric vehicles, battery charging and smart grid connectivity. The maintenance required by it is very less. The conversion of solar power to useful electrical power has less efficiency [2]. The efficiency is further reduce by energy elements (like inductor, capacitor) and in switching. To increase the efficiency of PV array, it is important to operate the array at its maximum power point. The MPP is varying with temperature and irradiance. This paper used P&O technique to track the MPP. Every time power is calculated and compared with the previous value. The value of power gets updated for maximum power.

II. PV CELL

PV cells are basic elements on manufacture of PV Power system. The voltage generated by one PV cell is between 0.5 and 0.8. Hence power generated is usually limited to few watts. To get the desired output no. of series and parallel PV cells are connected to make a module. Here in the Fig. 1, a standard equivalent circuit of the PV cell is shown.

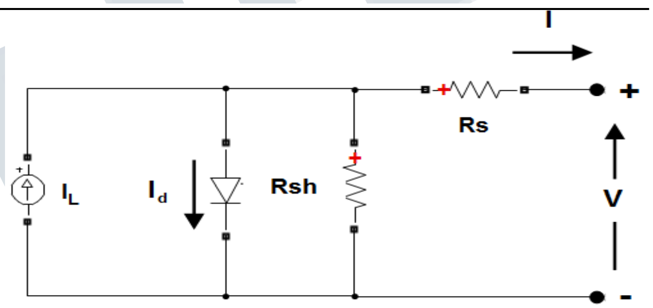

Fig. 1 Single diode arrangement of PV cell

The basic equation used to describe the PV cell is given below.

$$I_L = \{I_{SC} + K_i * (T - T_{ref})\}\frac{\beta}{1000} \qquad (1)$$

$$I = I_L - I_O\left[e^{\left\{\frac{q(V+IR_S)}{nkTN_{cell}}\right\}} - 1\right] - \frac{V + IR_s}{R_{sh}} \qquad (2)$$

$$I_o(T) = I_o\left(\frac{T}{T_{ref}}\right)^3\left[e^{\left\{\frac{E_{go}}{nV_t}\left(\frac{T}{T_{ref}}-1\right)\right\}}\right] \qquad (3)$$

Where,
I & V : Cell output current (A) and voltage (V);
Io : Cell reverse saturation current at T_{ref} (A);
T : Cell temperature in (^oC);
k : Boltzmann's constant, $1.3806 * 10^{-23}$ J/K;
q : Charge of electron, $1.6*10^{-19}$ C;
K_i : Short circuit current temperature coefficient at Isc (A/^oC);
β : Solar irradiation (W/m^2);
I_{sc} : Short circuit current (A);
I_L : Current generated due to light (A);
Ego : Band energy gap for silicon (V);

A : Ideality factor usually 1 for single diode;
T_{ref} : Reference temperature (^oC);
Ior : Cell saturation current at Tr (A);
Rsh : Shunt connected resistance (Ω);
Rs : Series connected resistance (Ω)

All the above equations are valid for single diode model. From equation, we can see that I_L is depends on solar radiation and temperature. Resistance due to contacts and semiconductor material is taken as series resistance and resistance between thin film layers around the cell is taken as shunt resistance. The shunt resistance is very high compared to series resistance. The variation in P-V curve due to temperature and irradiance shown in Fig 2 and Fig 3.

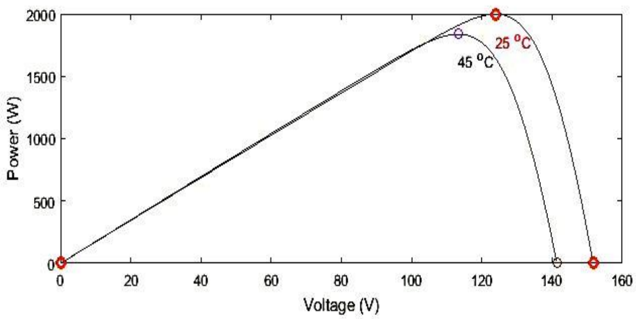

Fig. 2 Variation of MPP with Temperature

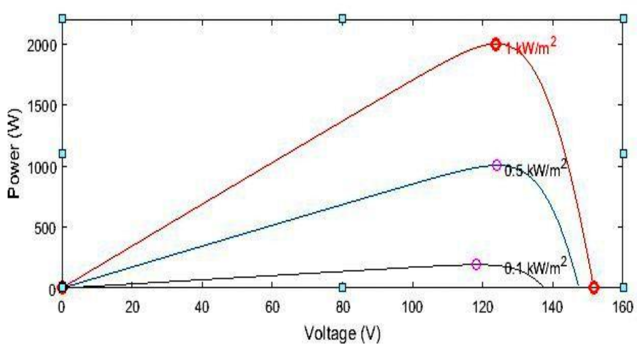

Fig. 3 Variation of MPP with Irradiance

III. P&O MPPT ALGORITHM

P&O MPPT method shown in Fig 4 is the most widely used technique to find the maximum power. In this technique, either the module voltage or current is periodically given a perturbation or the corresponding output power is compared with the previous value [3]. The perturbation causes the power of the solar module to very in the direction of peak power of P-V curve. If the power rises due to change, then the variation is continue in same track otherwise in reverse direction. When the steady condition is attained the algorithm fluctuates around the highest power point. In order to continue the power deviation low, perturbation magnitude is stay very low. The system is moved in such a way that it makes a reference voltage of the unit equivalent to the highest voltage of the unit [4].

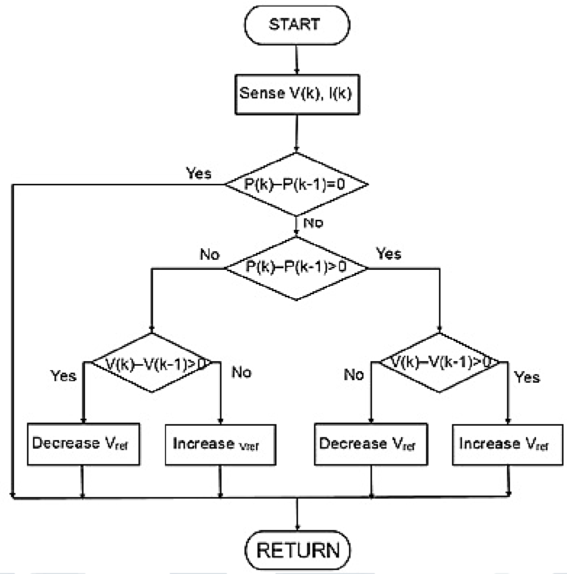

Fig. 4 Flow diagram of P&O Technique

IV. BOOST CONVERTER

The boost converter as shown in Fig 5 changes the input voltage to a upper output voltage [5]. It contains of a diode, switch, dc voltage source, capacitance and inductance. The transformation ratio for the boost converter can be determined by considering that the inductor and capacitor are so huge that we may take output voltage and output current as constant values.

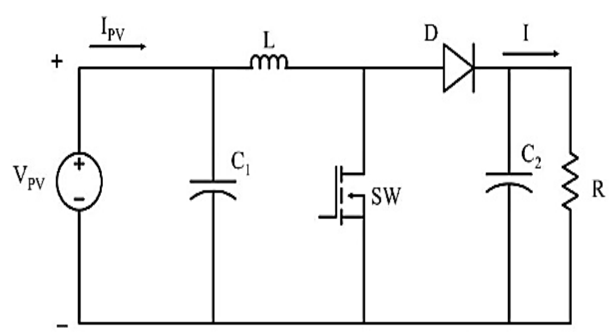

Fig. 5 Boost converter

$$Vo = \frac{V_{PV}}{1-D} \quad (4)$$

The above output voltage equation expresses the transformation ratio of boost converter in terms of duty cycle supposing constant frequency process. The critical value of inductance and capacitance are

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$$L_C = \frac{D(1-D)R}{2f} \quad (5)$$

$$C_C = \frac{D}{2fR} \quad (6)$$

V. MATLAB MODELING AND SIMULATION

The PV array consists of series and parallel combination of PV module. There are 13 series connected modules per string and 2 parallel string used. Each module has 20 PV cells. The main circuit consists of PV array, P&O subsystem and boost converter shown in Fig 6.

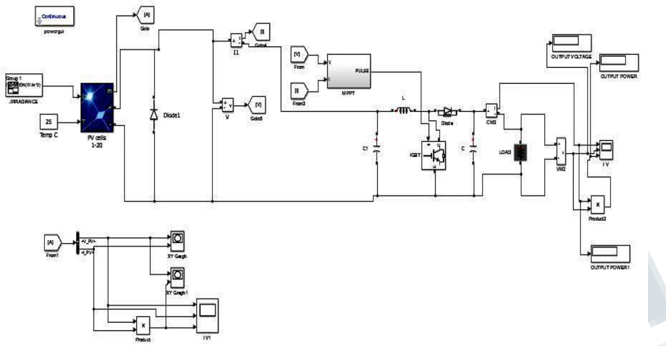

Fig. 6 PV system with boost converter

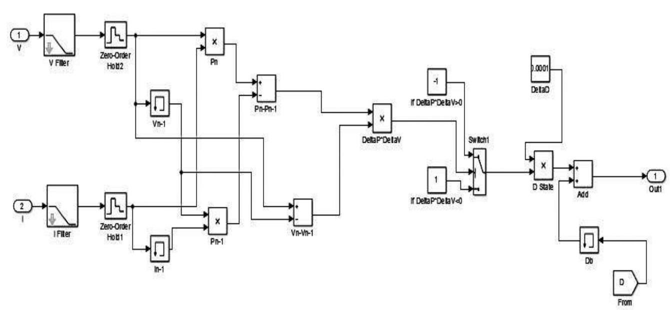

Fig. 7 P&O Technique

The pulse width of the switching device is shown in Fig 8.

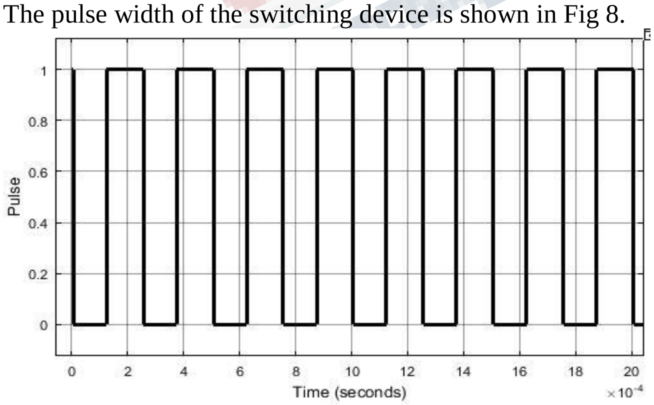

Fig. 8 Gate pulse to the switch

The output voltage and power in get from boost converter are 323 V and 2086 W respectively. The output of boost converter is shown below.

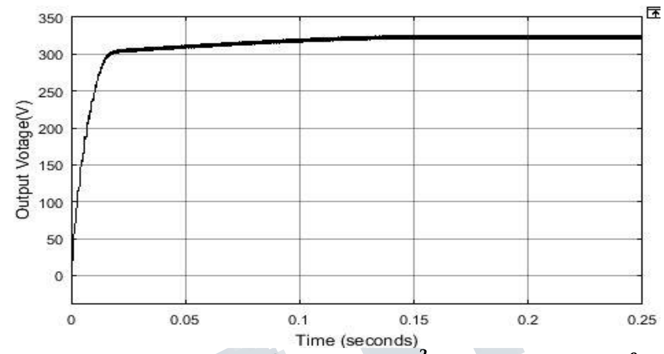

Fig. 9 Output Voltage for 1000 W/m^2 irradiance and 25^{o}C temperature

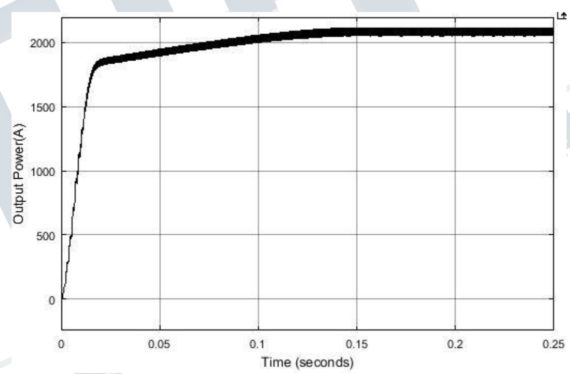

Fig. 10 Output Power for 1000 W/m^2 irradiance and 25^{o}C temperature

The variation in irradiance shown in Fig. 11 considerably affects the PV system. The following results show the variation of irradiance at fixed temperature of 25^{o}C.

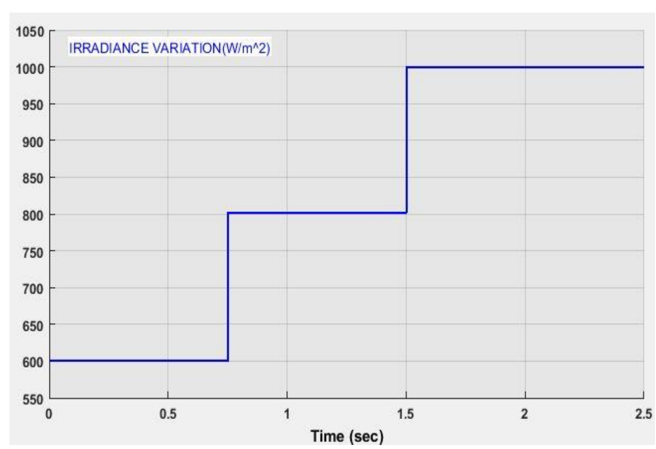

Fig. 11 Variation of irradiance to the PV array

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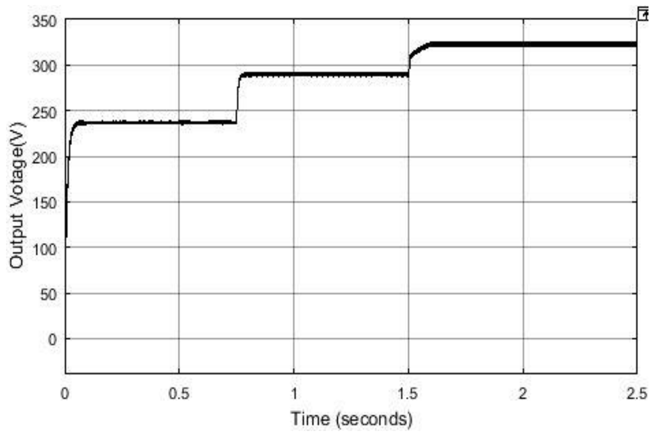

Fig. 12 Variation of Output Voltage

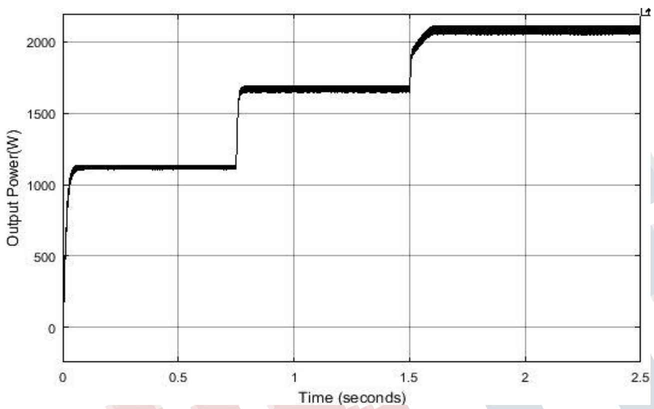

Fig. 13 Variation of Output Power

The performance of system is also compared for different values of inductance and capacitance. The output voltage, power and voltage ripple factor (VRF) is tabulated below.

TABLE I. CALCULATION OF VRF FOR 50Ω LOAD AND 1000W/m^2 IRRADIANCE

L (mH)	C_1 (µF)	C_2 (µF)	V_o (V)	P (W)	VRF (%)
1	60	200	323	2086	0.66
1	60	100	323	2083	1.32
1	10	100	298	1776	1.35
0.5	10	100	260	1350	1.58
0.5	60	200	320	2048	0.74
0.1	10	100	189	718	1.85

The parameters of boost converter are considerably affects the output. Harmonics can be reduced by using higher switching frequency by eliminating lower order harmonics.

VI. CONCLUSION

The PV system has been modelled and the P&O technique achieve the maximum power for 2 KW system. The voltage ripple factor is minimised by using suitable values of inductance and capacitance. There is a large drop in power for lower value of inductance but settling time reduces. For lower values of capacitance the harmonics get increased. For the better performance of the PV system, inductance and capacitance should have higher values.

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