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Design and Performance of Solar Photovoltaic System and Power Electronics Converter Using Perturb and Observation Mppt Techniques

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ABSTRACT- This paper presents 30KW solar photovoltaic (PV) design and showing maximum output in terms of voltage, current and power by using different weather parameters i.e. solar irradiance and temperature. For getting maximum power from PV system, the perturb and observation (P and O) technique is used. The output of PV is feeding to sepic dc-dc converter to maintain constant output across load. A solar PV matlab Simulink modeling is used to get better output. In this paper a solar PV modeling and power electronics converter design is present. The output power of solar photovoltaic array and sepic converter are constant by studying the graph performance.

KEYWORDS- Solar PV modeling, DC-DC converter, MPPT, simulink model, Results.

I. INTRODUCTION

The most of the electrical energy is provided by conventional power plant i.e. hydro, thermal, diesel. which is costly and production is not environment friendly and conventional system are using fossil fuels to produce electrical energy which are main cause of pollution and emission. The transmission and distribution is very difficult and costly. The above issues can be solved by producing energy at consumer end and eco-friendly. The non-conventional energy sources i.e. wind, solar, geothermal, biomass can be developed at consumer end. The solar energy is easily available and convenient for domestic, commercial and industrial consumers. The solar energy can be drawn from a solar photovoltaic cell system by exposing the solar cells or array in the sun.

The maximum power point techniques (MPPT) are used to get the maximum power output from solar photovoltaic cells or array. In this paper, the perturb and observation (P and O) technique is used to extract the maximum power point voltage (Vm), current (Im) and power (Pm) from solar PV system. This technique is also increased the efficiency of the solar PV array. The output of solar photovoltaic (PV) array is feeding to DC-DC converters to get a regulated output of converters using P and O algorithm to get better performance of solar PV and converter.

A. Photovoltaic Circuit and Modeling

An array comprises different PV cells and modules in series and parallel to get desired output and discussed as below.

B. Single PV cell

The fig (1) shows a single PV cell equivalent circuit model [1]. The I-V characteristics are described by mathematical equations.

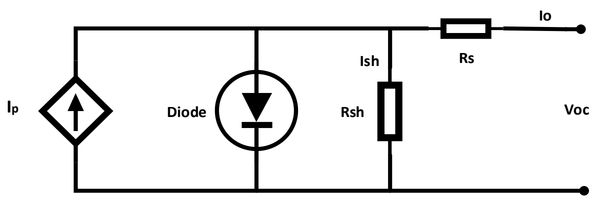

Figure 1: Single PV cell equivalent circuit

$$I_o = I_p - I_d - \frac{V_{oc} + IR_s}{R_{sh}} \qquad (1)$$

$$I_o = I_p - I_{rs}[\exp\left(\frac{V_{oc} + IR_s}{V_t}\right) - \frac{V_{oc} + IR_s}{R_{sh}} \qquad (2)$$

Where

I = Output current of solar cell (A), Ip = Solar Photovoltaic current (A), Id = Diode current (A), Irs = Diode reverse saturation current (A), Voc = Open circuit output voltage (Volt), Rs = Series Resistance of PV cell (ohm), Rsh =Shunt resistance of PV cell (ohm), Vt = Thermal voltage of solar PV module as

$$V_t = \frac{a\ k\ t\ N_s}{q} \qquad (3)$$

Where

Ns = No. of series connected cells, a = Diode ideality constant $(1 \leq a \leq 2)$, Ns = No. of series connected cells, k = Boltzman constant (1.38065 X 10-23 J/K) , q = Electron charge (1.6022 X 10-19 C), T = Actual temperature (oK)

A. Modeling of PV array

In this paper, there has been developed a design of 30 KW solar PV system. The I-V characteristics of solar PV cell depends on weather or atmosphere conditions and PV cell contact resistances i.e Rs and Rsh. The variation in solar current (Ip) is depending on the variation of solar insolation and temperature. But for getting a best I-V curve fitting, the suitable value of Rs and Rsh [1] should be choosen. The photovoltaic current equation for solar PV cell is:

$$I_p = \{I_{scn} + K_i(T - T_r)\frac{G}{G_r} \quad (4)$$

Where Iscn is the reference short circuit current by solar light generated in Ampere at Tr = 25oC (reference temperature) and Gr = 1000 W/m2 (reference solar insolation), ΔT = T – Tr (oK), G = actual solar insolation on the surface of solar PV cell and Ki = short circuit temperature coefficient (A/oK).
In solar PV cell, the diode reverse saturation current (Io) is depending on temperature [1] and the modified [1] equation is:

$$I_{rs} = \frac{I_{scn} + K_i * \Delta T}{\exp\left[\frac{V_{oc}+K_v*\Delta T}{V_t}\right] - 1} \quad (5)$$

Where Kv is open circuit voltage temperature coefficient (V/oK). The equation (5), improves the performance of PV model, simplify the model, remove the errors in output parameters and smoothing the I-V curve.
A single PV cell produces approximately 3 W and 0.6 V. The more power can be obtained from PV cell, when some cells in series and some parallel [2]. If Nss are the total no. of cells connected in series and Npp are the total no. of cells connected in parallel then the equation (2) will be written as:

$$I_o = N_{pp}I_p - N_{pp}I_o[\exp\left(\frac{V_{oc} + IR_s}{V_t}\right) - \frac{N_{pp}V_{oc} + IR_sN_{ss}}{N_{ss}R_p} \quad (6)$$

This array [2] is having 8 modules are connected in series and 18modules are connected in parallel and fig(2) shows the matlabsimulink modelof a PV array.

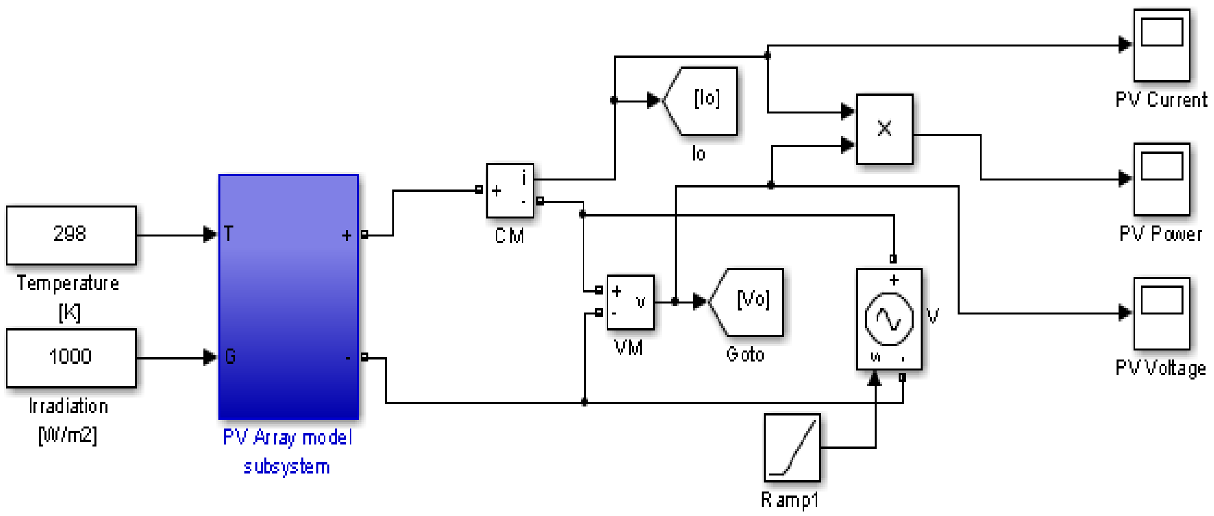

Figure 2: Solar PV modeling matlab circuit

It has seen that at different irradiance, the PV output current is reduced at decreasing irradiance and current-voltage (I-V) and power-voltage (P-V) characteristics are shown in fig(3) and fig(4).

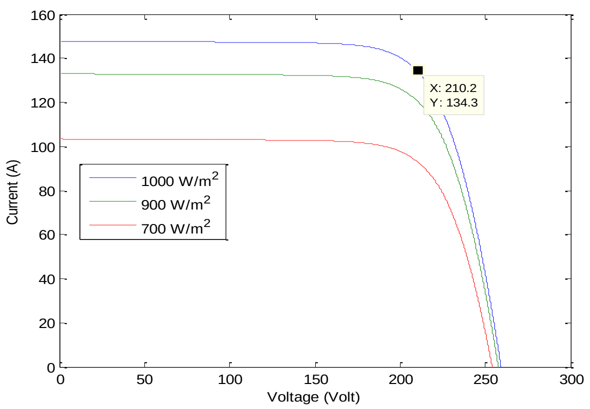

Figure 3: Current-Voltage (I-V) characteristics of PV array

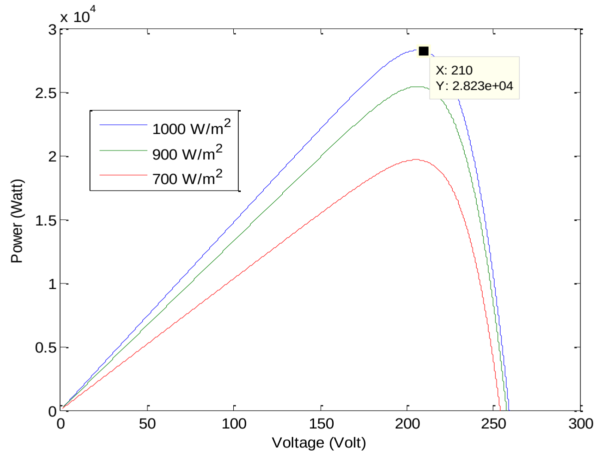

Figure 4: Power-Voltage (P-V) characteristics of solar PV array

At various temperature i.e. if temperature is reduced then the PV output voltage as well as power is reduced. The current-voltage (I-V) and power-voltage (P-V) characteristics are shown in fig (5) and fig (6) below.

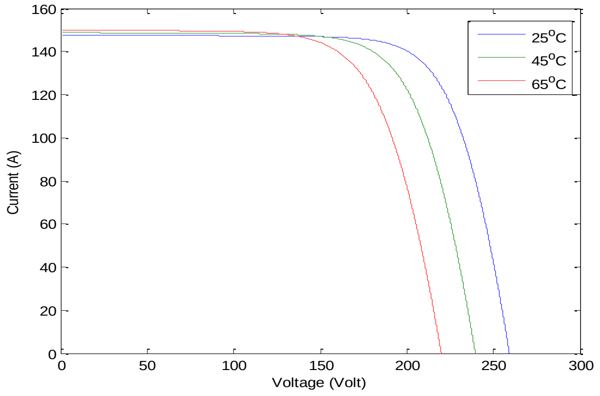

Figure 5: I-V characteristics of solar PV array

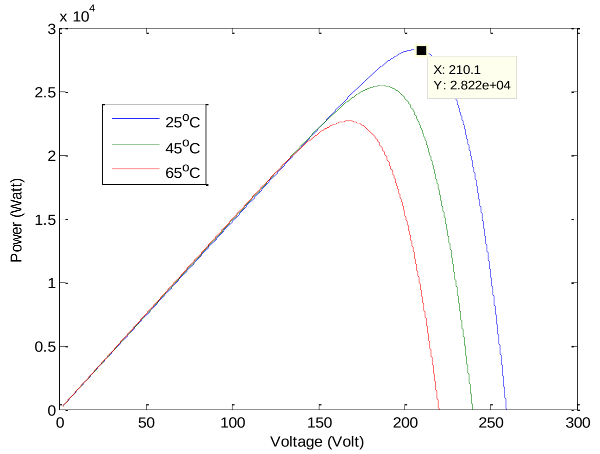

Figure 6: P-V characteristics of solar PV array

II. DESIGN PARAMETERS OF DC-DC SEPIC CONVERTER

Sepic converter convert the variable input into regulated output. When MOSFET switch is ON [3] the inductor L1a is charge by input voltage and capacitor Cs charge the inductor L1b and capacitor Co and develop output voltage. When switch is OFF, the L1a discharges through Cs, diode and produce voltage across load. The inductor and capacitors reduces the ripple and produces smooth output voltage. The switching frequency is used 100 Khz and sepic converter is shown in fig (7).

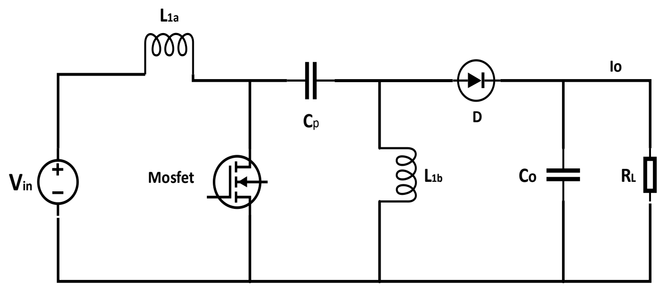

Figure 7: Sepic dc-dc converter

The design equations as:

$$D = \frac{V_o}{V_{in} + V_o} \qquad (7)$$

Maximum duty cycle occurs at Vin(min).

$$L_{1a} = L_{1b} = \frac{V_{in(\min)} * D_{max}}{\Delta I_L * f_s} \qquad (8)$$

$$C_0 = C_s = \frac{I_o * D_{max}}{\Delta V_C * f_s} \qquad (9)$$

Where

D = Duty cycle, Vo = output voltage (Volt), Vin = Input voltage (Volt)ΔIL = (0.5% to 1% 0f output current), Io = output current (A), ΔVc = Capacitor voltage ripples , fs = Switching frequency (Khz) and C = Capacitance (Farad), L = inductance (Henry).

III. PERTURB AND OBSERVATION ALORITHM

The Perturb and observation (P and O) techniqueis the hill climbing technique [4], it can extract the maximum maximum power from a photovoltaic system. In changing temperature and irradiance, it can extract maximum power point voltage (Vmpp), maximum power point current (Impp) and available maximum power (Pmax). This algorithm oscillates at maximum power point. The perturb and observation method can extract the maximum power and fed to asepic DC-DC converter to get a constant output voltage, current and power [5]. A flowchart is shown in fig (8), in which the Pnew is compared with Pold and perturbation continuous upto maximum power. After maximum output power the duty cycle is decreased and before maximum output power the duty cycle is increased.

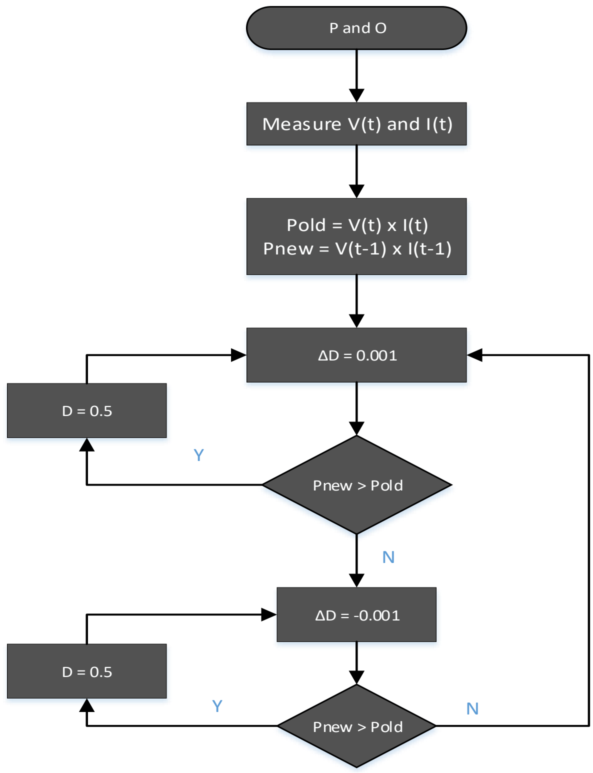

Figure 8: Perturb and Observation algorithm

IV. PV ARRAY PERFORMANCE WITH MATLAB SIMULATION

The perturb and observation technique is used to extract the maximum power from PV system [5]. The output of solar PV array is fed to as input of sepic converter. The output of converter is maximized by changing the duty cycle of P and O. When the output power decreased the tracker starts perturbation and set the duty cycle at maximum power tracking point. A matlab simulink circuit of sepic converter with P and O is shown in fig.(9) and its input and output current (I), voltage (V), power (P) waveform is shown in fig. (10), (11), (12) with constant temperature (25oC) and irradiance (1000 W/m2).

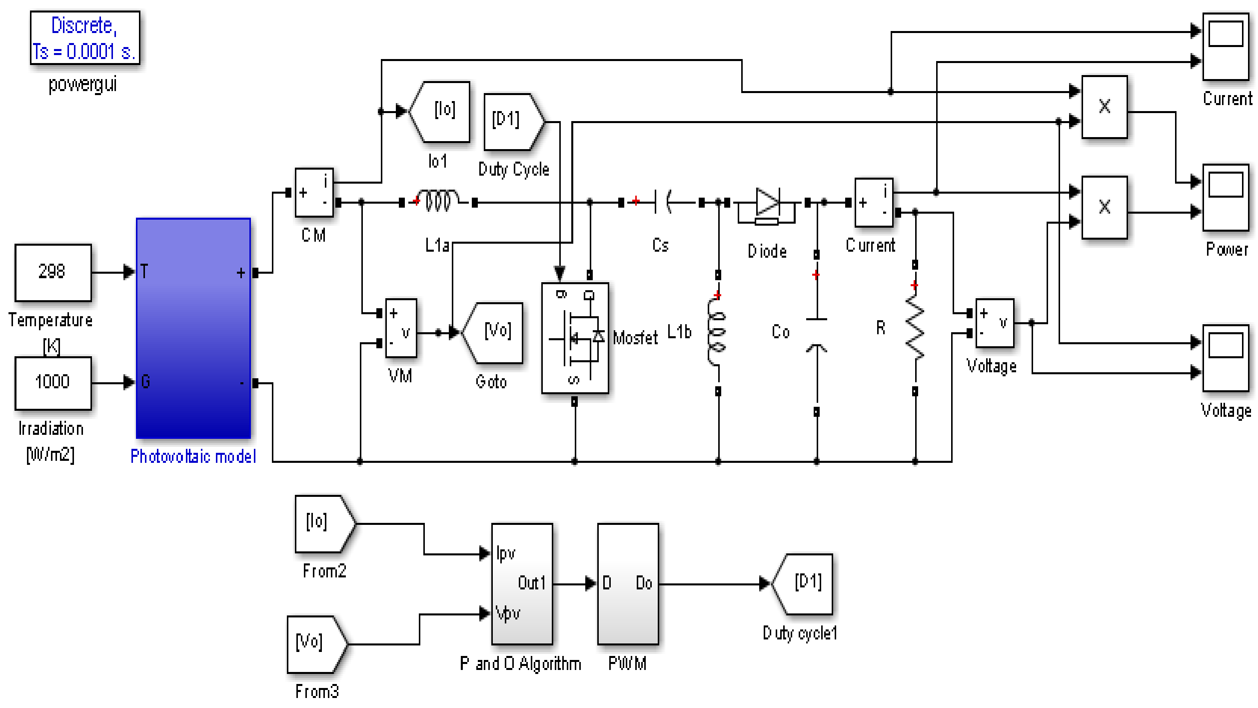

Figure 9: Sepic converter with P and Omatlabsimulink

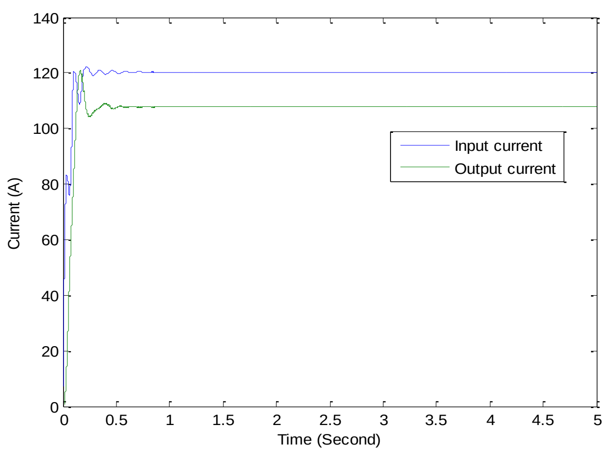

Figure 10: Input and output currents

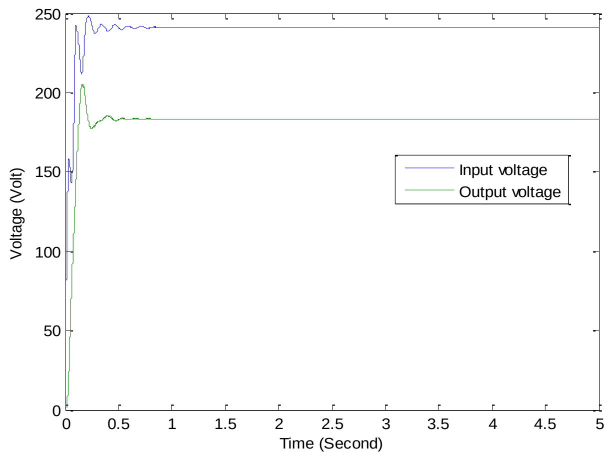

Figure 11: Input and output voltages

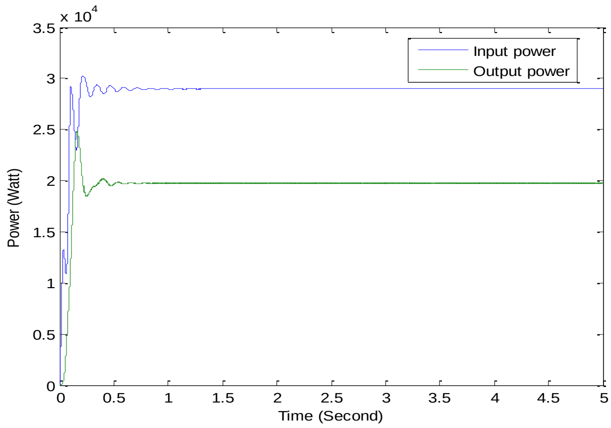

Figure 12: Input and output power

V. RESULTS AND DISCUSSION

This paper has a design of 30 KW solar photo-voltaic (PV) system and it is showing from PV graph in which maximum power is 28.8 KW. This power is connected to sepic converter in which a 100 Khz switching frequency is used. The P and O algorithm is used to extract the power from photovoltaic array. The converter is being fed with 237.8 V and 119.4 A, this input of converter is producing the output power 20.4 KW at 186.2 V and 109.8 A. But output is constant and ripple free.

VI. CONCLUSION

This paper comprises a design of 30 KW photo-voltaic (PV) array and deals with P and O control techniques and the inductors and capacitors of converter is designed with <1% current ripple and 1% in voltage ripple. The output of converter is ripple free because of larger value of inductors and capacitors. Because of many components, this system is costly and larger loss and producing low power output.
It has been seen in PV graphs that any variation in atmospheric parameters i.e. temperature, irradiance will be considered by the control techniques and producing a proportional output.

REFERENCES

[1] M.G. Villalva, J.R. Gazoli, E. Ruppert F. "Modeling and circuit
[2] based simulation of photovoltaic arrays" University of Campinas-UNICAMP, Brazilian journal of power electronics, University of Campinas -UNICAMP, Brazil, Brazilian journal of power electronics, 2009.
[3] S. Sumathi et al. "Solar PV and wind energy conversion systems"
[4] Green energy technology, Springer International Publicing Switzerland, 2015.
[5] Dr.S.Venkatanarayanan, C.Sakthivinayagam "MPPT for PV Using
[6] Coupled Inductor SEPICConverter for Standalone Power System"
IEEE, 2016.
[7] M. R. Banaei*, M. R. Shirinabady**, Mehdi Mirzaey "
[8] MPPT control of Photovoltaic using sepic converter to reduce the
[9] input current ripples" M. R. Banaei et al Int. Journal of Engineering
[10] Research and Applications Vol. 4, Issue 1(Version 2), January 2014.
[11] [5] Mr.K.Natarajan1, M.Supriya2, Y.Abinaya3, P.Nandhakumar4,
[12] G.R.Samrajesh "Designof asepicconverterforsolar PV system"
[13] Conference Paper· March 2017