Modeling of PV arrayUsing P&O algorithm in Boost Converter

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***Abstract*—The paper describes in detail the generation of solar power using a single diode photovoltaic cell (PV) model (SDPVM) in MATLAB Simulink GUI platform. The paper has done the Solar PV module modelling in MATLAB (Simulink) platform under different temperature and varying solar radiation. Current-Voltage (I-V) and Power-Voltage (P-V) curve are plotted in MATLAB Simulink. Here the tracking of maximum power is done using Perturn and Observer (P&O) algorithm. The solar output voltage is amplified using boost converter.The effect of solar radiation on different parameters are obtained in the paper. The simulation permits the user to change the number of PV panels so that to evaluate the number of panel assessment in regards of cost, optimization efficiency.**

Keywords-solar cell parameter, photovoltaic model, P&O, Boost Converter, MATLAB Simulation Modeling.

I.INTRODUCTION

Sunlight, wind, tides etc are naturally available renewable energy sources that can share with conventional fossil fuels for power generation. The cost of ordinary vitality is rising and sun powered vitality has developed to be a promising option. They are bottomless, contamination free, appropriated all through the earth and recyclable vitality sources. Photovoltaic (PV) array are connected in parallel or in series connected cells that depend on the climatic decides [1](e.g. sunlight based insolation value and temperature) for the output power generation.The paper describes in details the generation of power using solar energy with a basic solar model. The paper defines the effect and utilization of environmental parameter for the maximum power generation from PV cell. This paper focuses for giving in details a simplified model of single diode PV in MATLAB Simulation.

The PV model is basically of two types: 1) double-diode solar model (DDSM) [2]2) single-diode solar model (SDSM) [3]. The DDSM gives more accurate significant result in I-V curve than the SDSM [4],[5]. But DDSM shows more difficulty with respect to parameter effect. SDM shows positive parameter effect and a SDM ideal model is designed which shows a direct relation with the parameter effect [6]. Many papers have ignored the effect of shunt and series resistances R_{sh} and R_s on the model accuracy [7]-[12].

The paper is divided into following sections. Section II consists of complete theory on PV modeling. Section III covers Perturn & Observer (P&O) algorithm. Section IV describes the theory on Boost converter. The section V includes the MATLAB simulation result of boost converter of PV Modeling. Section VI showsthe simulation result under various environmental conditions. Section VIIreveal with the conclusion of the paper.

II.PV MODELING

Power is generated on the solar cell using sun rays by the photovoltaic effect. PV framework normally shows nonlinear attributes as per a diode which shift with the brilliant force and cell temperature. A PV cell can generate power of 2W at 0.5V [15]. So number of cells can be connected in parallel or in series to obtain more power. The maximum power of PV panel are shown in (1)

$$P_{max} = \gamma V_{max} * I_{max} = V_{oc} * I_{max} \qquad (1)$$

Vmax and Imax are the maximum output voltage and current from PV module of the panel, fill factor (γ) of a cell is a measure of quality of a cell [16].The PV circuit diagram is shown in Fig.1 consists of simple photovoltaic array (PVA) presented by I.H.Altas et.al in his paper [13]. The model its effect on different environmental parameter is also presented in brief by L.Cristaldi et.al in his paper [14].

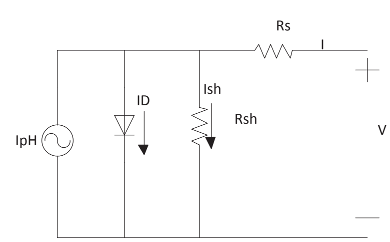

Fig. 1. Single diode - PV model

$$I = I_{ph} - I_d - I_{sh} \qquad (2)$$

According to the KCL, the current at output I [17] is equal to the source current proportional Iph, Id represents the diode current, Io is the saturation current of the module.

$$Id = Io[\exp\left(\frac{V}{A.Ns.VT}\right) - 1] \quad (3)$$

V is the voltage given to the diode.

$$VT = {K.Tc}/_{q} \quad (4)$$

VT= 26 mV at 300 K for silicon cell, T_c is the PV cell temperature (K), k is the Boltzmann constant of 1.381* 10^23J/K, q is the electron charge (1.602*10^19 C). VT is the thermal voltage because of its exclusive dependence of temperature[18-20]. Ns PV connected solar cells, A is the PV cell technology dependent on ideality factor.

In this section the characteristic equations of solar PV module are described in (5), (6), (7) & (8) for the PVmodule is applied in MATLAB [21].

The output characteristics of photovoltaic cells is

$$I = Iph - Io\left[\exp\left(\frac{(V+IRs)}{a}\right) - 1\right] - \frac{V+IRs}{Rp} \quad (5)$$

$$Iph = [Isc + Ki(T-298)]X\,{Ir}/_{100} \quad (6)$$

Where Isc: short circuit current (A); K is the short circuit coefficient at 25°C and 1000 W/m^2; T is the operating temperature (K); Solar irradiation (W/m2) ;

Module reverse saturation current Irs :

$$Irs = Isc/[\exp({qVoc}/_{NsKnT}) - 1] \quad (7)$$

Where q the electron charge=1.6X10^-19C; Voc is the open circuit voltage (V);

The module immersion current Io changes with the cell temperature, given by:

$$Io = Irs[\frac{T}{Tr}]\text{^}3\exp[\frac{qXEg}{nk}\left(\frac{1}{T} - \frac{1}{Tr}\right)] \quad (8)$$

Where Tr is the ambient temperature= 298.15 K; Eg is band gap energy of the semiconductor=1.1ev.

Table I reflects the parameters of MX X-60 of PV panel that is used in the paper [26].The open circuit voltage Voc is 21.1V relating to short circuit current Isc from 0 to 3.11A. Fig.5, 6 demonstrates the effect of PV curve on varying the sunlight based insolation level at a temperature of 25^{O}C. It is shown that the short out present and in addition the power increments with respect to solar insolation level, while almost no adjustment in Voc. The pinnacle estimation that the result of the output speak to the Maximum power (Pmax). The sun based module ought to dependably be worked in this district in order to separate the most extreme power for a given information conditions. So number of local tacking happens.

TABLE I. Electrical Characteristics of MSX-60

Maximum power (Pmax)	60W
Maximum Voltage (Vmp)	17.1V
Maximum Current (Imp)	3.5A
Minimum Power (Pmin)	58W
Short-circuit current (Isc)	3.2A
Open-circuit voltage (Voc)	21.1V
Temperature coefficient of open-circuit voltage	–(80±10)mV/°C
Temperature coefficient of short-circuit current	(0.065±0.015)%/°C
Temperature coefficient of power	–(0.5±0.05)%/°C
NOCT2	47±2°C

III. MAXIMUM POWER POINT TRACKING (MPPT)

PV module relies upon the sun rays alter in course of the sun insolation value and in temperature [22]. Likewise there is a solitary maximum power point of module for a specific working condition and therefore it is wanted that the PV module works near maximum power point, i.e., yield of this module tends to be close to MPP. The phenomenon of tracking the maximum power from the P-V curve gives the maximum power point tracking (MPPT). Boost of PV panel control enhances the use of the sun oriented PV module. Numerous MPPT calculations had been developed earlier. The most widely recognized algorithm are P&O, incremental conductance (Inc), Hill climbing technique, Fractional Voltage are portrayed in [23]. Here in this [24] work the most extreme power following strategy utilized is the P&O. The output of the MPPT changes in accordance with the duty cycle (D) of the converter. In Table II explains the MPPT algorithm [25].

Table II give conclusion as controlled voltage (Vc) of the converter has to be decrease to have positive perturbation i.e. to maximize the power.

Table II. P&O algorithm of MPPT

Perturbation in panel voltage (dV)	Effect on power (dP)	Condition for next perturbation in panel voltage	Perturb in 'd'	Perturb in 'Vc'
Positive	Positive	Positive	Negative	Negative
Negative	Negative	Positive	Negative	Negative
Negative	Positive	Negative	Positive	Positive
Negative	Negative	Negative	Positive	Positive

IV. DESIGN OF DC-DC BOOST CONVERTER

A DC-DC boost converter produces output more than the input voltage [34]. Here in this paper the output voltage from the PV module is fetch as input into the converter. The MPPT controller controls the duty cycle of the converter to have the desired output. The duty cycle (D) of power device is the ratio of the ON–time to the total time of any cycle which helps to controls the output voltage. This gives the yield voltage higher or lower than the input voltage, in perspective of the duty-cycle (D) [27-29].

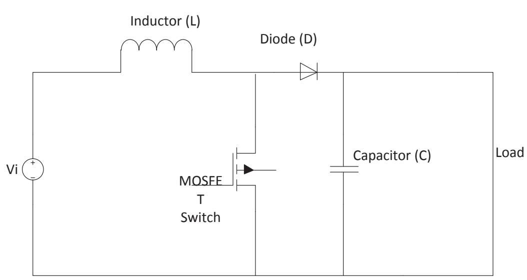

Fig. 2. Boost converter using MOSFET switch

V.SIMULATION RESULT OF SDVM USING BOOST CONVERTER

In this section solar PV model is designed using dummy solar cell as input current source, a diode, and resistances [30].

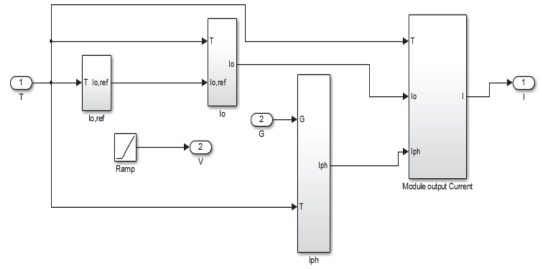

Fig.3. PV module with Ns as 36 and Np as 1

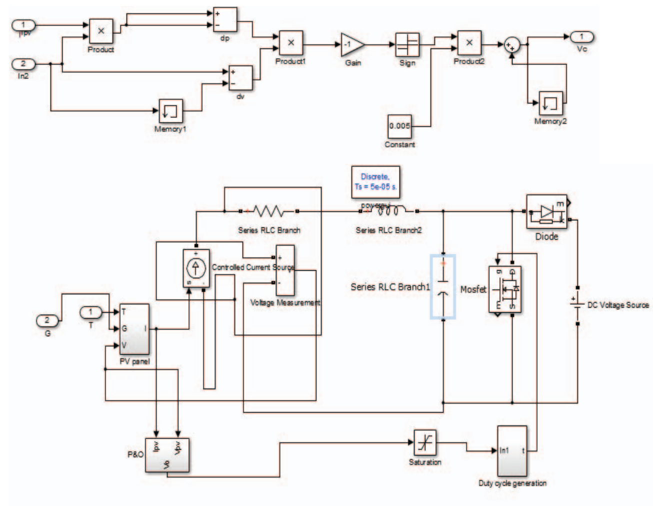

Fig.4. P&O algorithm with Boost converter

VI.RESULT

A. Effect of IV and PV graph

The simulation of P-V and I-V graph show in Fig. 5 andFig.6 as I_{SC}at 3.11A, V_{oc} at 21.8V and maximum power (P_{mp})as 57W [31].

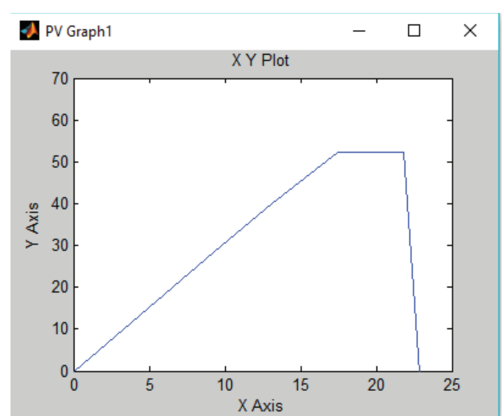

Fig.5.P-V graph of PV module

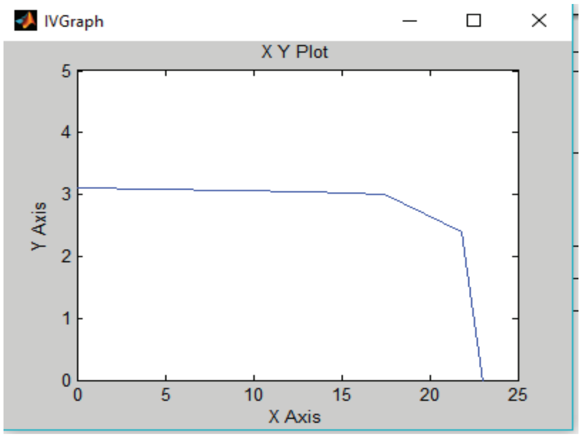

Fig. 6I-V graph for PV module

B.Effect of irradiance

The yield energy of a sunlight based PV module emphatically relies upon the sun powered illumination of light.It is clear from Fig.5 that output current of PV gets increased with increase in radiation and vice-versa. However V_{oc}does not changes with irradiance level [32].

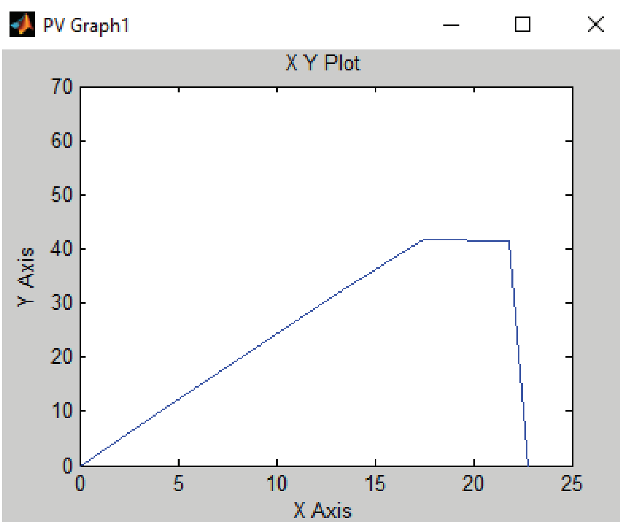

Fig.7 Effect of irradiance level on P-V curve

C.Effectof temperature on I-Vgraph

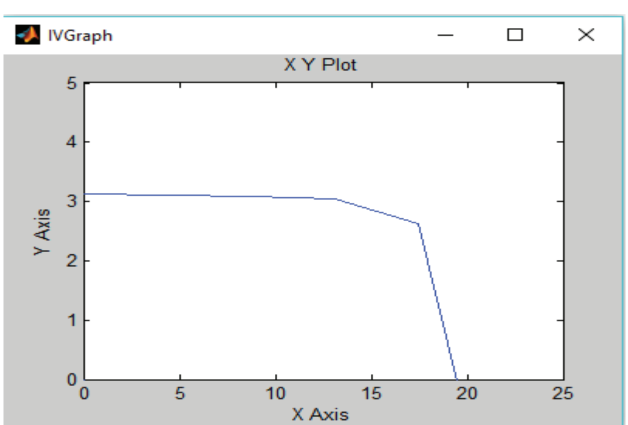

Fig.8. Effect of temperature on I-V curve

Fig.8 shows atmospheric temperature effect on I-V graph. The graph shows that the current does not affect much on the temperature. But the voltage depends on temperature. The module voltage increases as the temperature increases.

D. MPPT for constant duty cycle (0.6)

The output voltage of PV module is connected at the Boost converter input to obtain a steady duty cycle equal to 0.6 [33]. The reproduction after effects of the yield energy of the module input energy of the Boost converter and the yield energy of Boost converter for various sunlight based irradiance after recreation are not appeared in the paper.

VII. CONCLUSION

MX X 60W module parameter are used here to acquire the MATLAB/Simulink for various estimations of insolations. The Pmax is gotten utilizing the M-record with P&O strategy. Likewise the module voltage Vmp and Current I, control Pmax esteems acquired are genuinely same as showed by the producer of MX X 60W sun powered board. Consequently the proposed model show in conjunction with MPPT calculation is utilized with Boost converter to have proper I-V and P-V graph.

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