Modelling and Simulation of Buck-Boost Converter

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Abstract-This paper presents a unique step-by-step procedure for the simulation of photovoltaic modules with Matlab/ Simulink. The objective is to design & simulate a controller for the unlimited solar power drawn from the sun & produce a higher voltage o/p through the d.c. to d.c. (Buck-boost) converter .One-diode equivalent circuit is employed in order to investigate i-v and p-v characteristics of a typical 36W solar module. The proposed module is designed with different icons, dialogue box like simulink block libraries. This PV module is interfaced to the buck boost converter and the performance has been studied by the matlab simulink.

Keywords- Photovoltaic (PV), Buck-Boost Converter, simulation of PV model, simulation results.

I. INTRODUCTION

Worldwide energy consumption has increased rapidly due to world population growth. Since amount of fossil energy source has no longer enough, renewable energy sources such as solar power, wind power, geothermal power, and fuel cell are considered to meet the global demand for energy(1). Solar energy is a very attractive renewable source with a long service life and high reliability. But because of its high cost and low efficiency, energy contribution is less than other energy sources. It is therefore essential to have effective and flexible models, which perform easy manipulation of certain data (irradiance, temperature)investigate how to get its maximum performance as possible(2).The fundamental element in solar power generation system is the solar cell or photovoltaic (PV) cell that MODELLING OF PV MODEL. The photovoltaic (PV) cell is basically a p-n junction fabricated in a thin wafer of semiconductor. The solar energy is directly converted to electricity through photovoltaic effect. PV cell exhibits a nonlinear P-V and I-V characteristics which vary with cell temperature (T) and solar irradiance (S). Different equivalent circuit models of PV cell have been discussed in literature [3].The system performance can be optimized by connecting the pv model with buck-boost converter[4].I n this paper, a step-by-step procedure for simulating pv module with subsystem blocks, different icons and dialog in the same way as matlab/simulink block libraries is developed. Section-1 represents pv module equivalent circuit and equations for I_{pv} and V_{pv}.Section -2 represents the data sheet for 36W solar pv module for simulation.
Section -3 represents the step-by step procedure of pv module with simulation results and section -4 represents interfacing of pv module with buck-boost converter with simulation results.

II. MODELLING OF PV MODULE IN MATLAB

A Photovoltaic cell is a device used to convert solar radiation directly into electricity. It consists of two or more thin layers of semiconducting material, most commonly silicon. When the silicon is exposed to light, electrical charge are generated. A PV cell is usually represented by an electricalcircuit equivalent one-diode model shown in fig.1

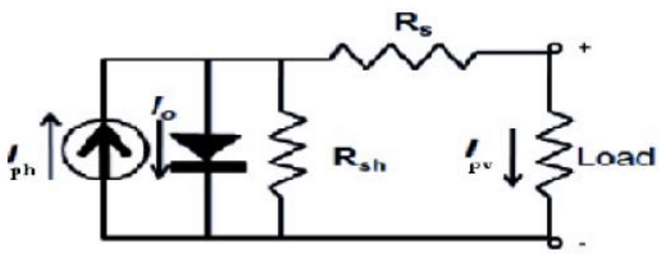


Figure 1. PV cell modeled as diode circuit

III. NOMENCLATURE

V_{pv} is output voltage of a PV module (V)
I_{pv} is output current of a PV module (A)
T_r is the reference temperature = 298 K
T is the module operating temperature in Kelvin
I_{ph} is the light generated current in a PV module (A)
Io is the PV module saturation current (A)
A = B is an ideality factor = 1.6
k is Boltzmann constant = 1.3805×10^{-23} J/K
q is Electron charge = 1.6×10^{-19} C
R_s is the series resistance of a PV module
I_{SCr} is the PV module short-circuit current at 25 ^oC and 1000W/m2 = 2.55A
K_i is the short-circuit current temperature co-efficientat I_{SCr} = 0.0017A / ^oC λ is the PV module illumination (W/m 2) = 1000W/m2
E_{go} is the band gap for silicon = 1.1 eV
N_s is the number of cells connected in series
N_p is the number of cells connected in parallel

Module photo-current-I_{ph}

$$I_{ph}= [I_{scr}+K_i(T-298)]\lambda/1000 \quad -(1)$$

Module saturation current-I_{rs}

$$I_{rs}= I_{scr}/[\exp(qV_{oc}/N_skAT)-1] \quad -(2)$$

The module saturation current I_0 varies with the celltemperature, which is given by

$$I_o= I_{rs}[T/\exp[q*E_{go}/Bk\{1/Tr-1/T\}] \quad -(3)$$

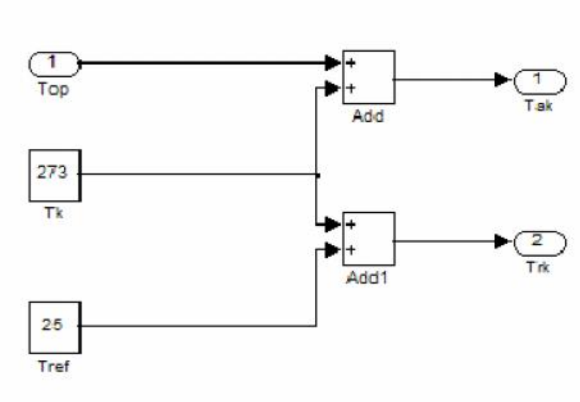
The current output of PV module-Ipv is

$I_{pv} = N_p * I_{ph} - N_p * Io[\exp\{q*(V_{pv}+I_{pv}R_s)/N_sAkT\}-1]$ -(4)

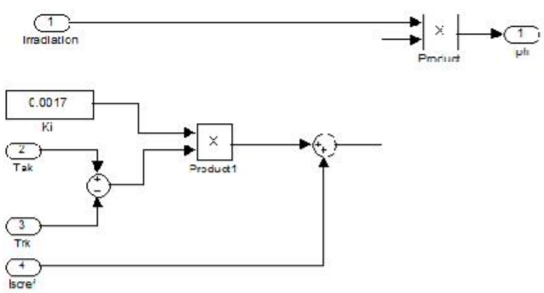
IV. STEP BY STEP PROCEDURE FOR MATLAB MODELLING OF PV MODULE

The PV module has been modeled by using the above equations.The Subsystems has been modeled step-by step by using those equations as shown below using MATLAB:

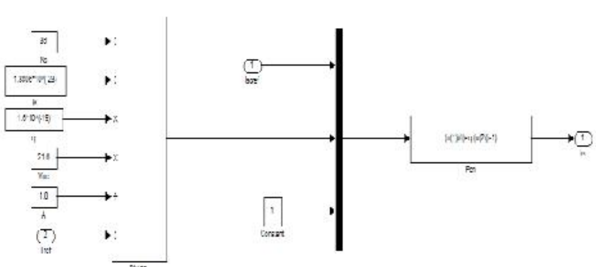
STEP-1 .This model converts the module operating temperature given in degree Celsius to Kelvin.



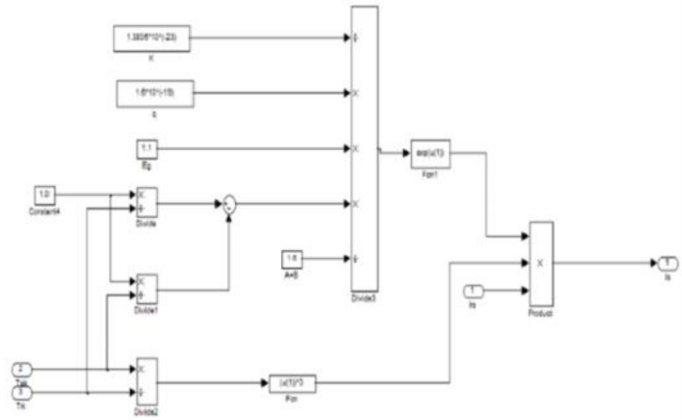
STEP-2.Calculation for I_{ph}



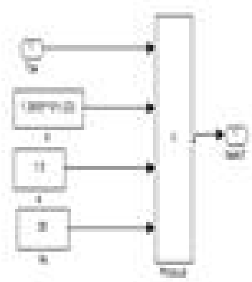
STEP-3.Calculation for I_{rs}



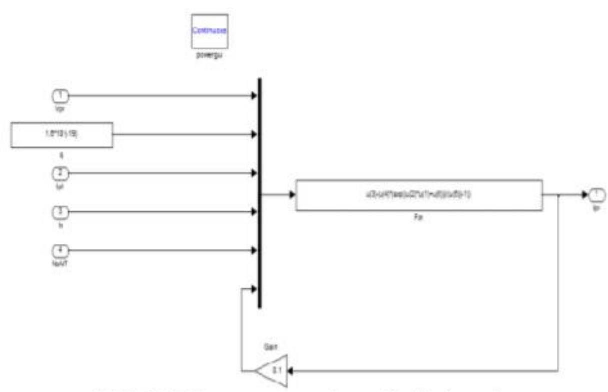
STEP-4.Calculation for I_s



STEP-5 CalculationforNsAkT



STEP-6 Calculation for I_{pv}



STEP-7 Inter-connection of all six subsystem

V. SIMULATION MODEL OF PV MODULE

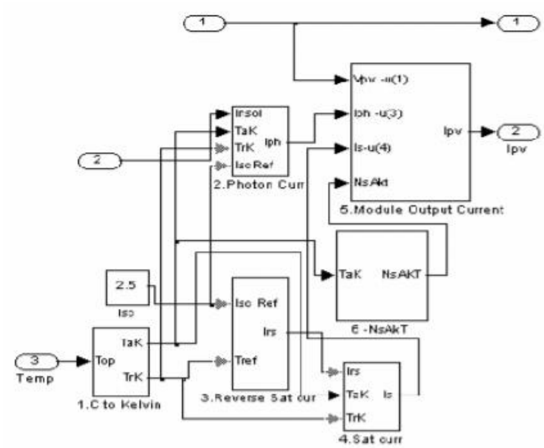


Fig-2 Simulation of PV-module

VI. CHARACTERISTICS OF PV MODULE

The simulation results of I-V curve and P-V curve of PV model for different solar irradiation and constant temperature

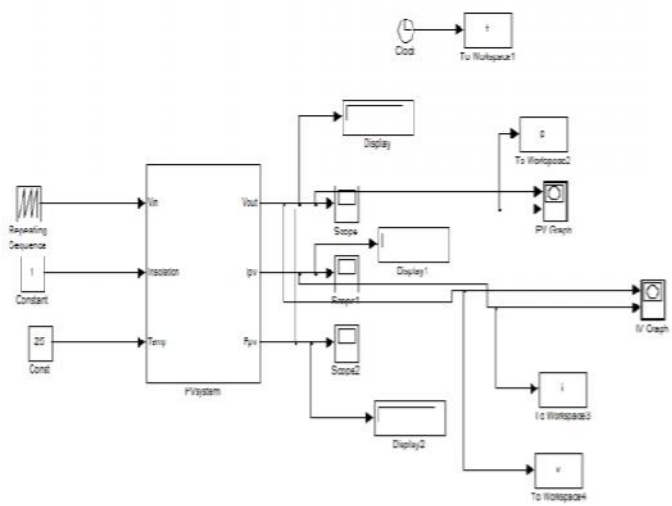
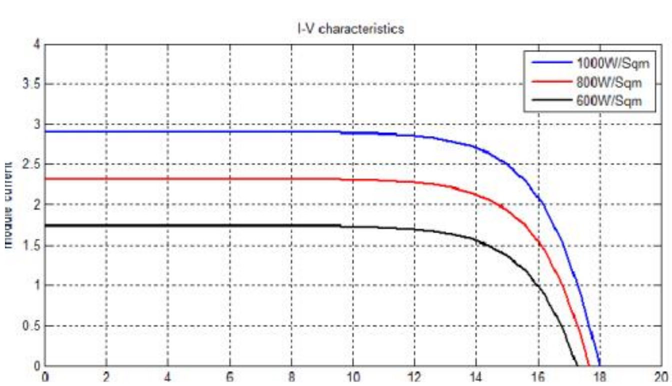
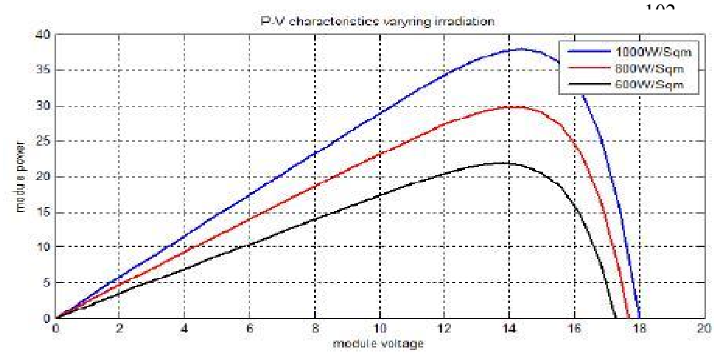
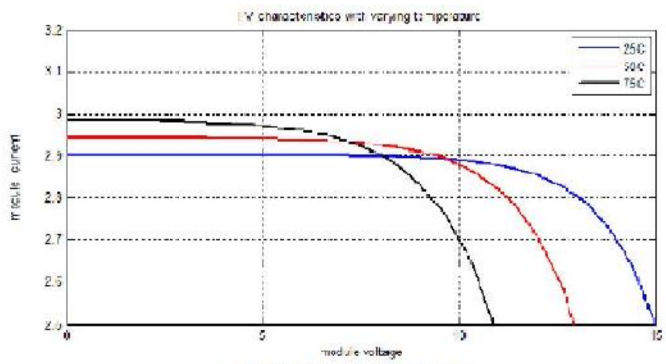


Fig-3: P-V & V-I characteristics with varying irradiance & constant temperature.

From the above for different solar irradiation & constant temperature, it can be observe that current & power of the PV module increases with increasing solar irradiation. The simulation results of i-v curve and p-v curve of PV model for constant solar irradiation and different temperature are shown in Fig-4







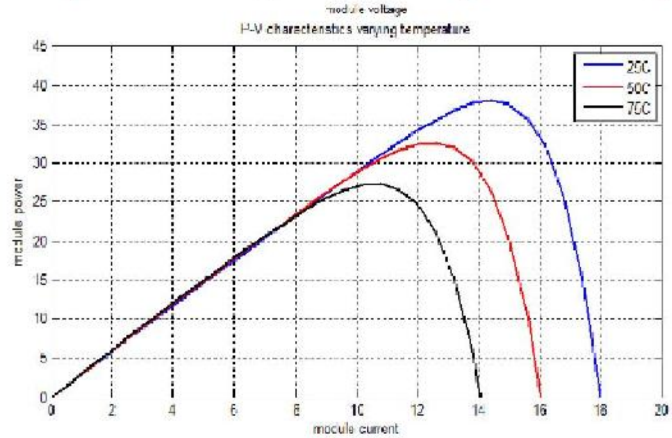


Fig-4. P-V & V-I Characteristics with varying temperature & constant irradiation

VII. MODELLING OF BUCK-BOOST CONVERTER

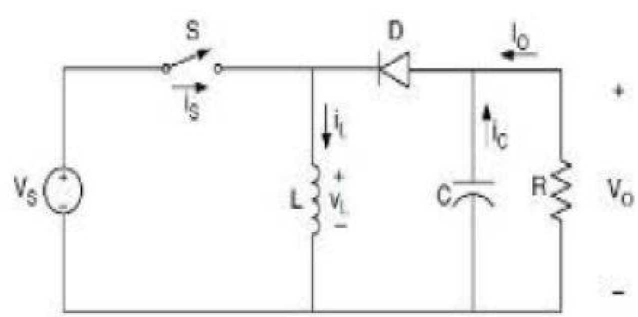
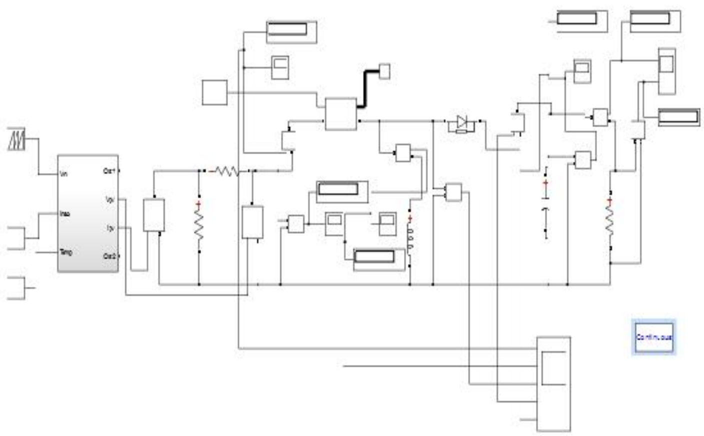


Fig-5 Schematic diagram of Buck-boost converter

A buck boost converter is a DC-to-DC power converter with an output voltage either greater or smaller than its input voltage. It is a combination of the buck converter topology and a boost converter topology in cascade. The output to input conversion ratio is also a product of ratios in buck converter and the boost converter. The output voltage is controlled by controlling the switch-duty cycle. The term D is the duty ratio and defined as the ratio of the on time of the switch to the total switching period. This shows the output voltage to be higher or lower than the input voltage, based on the duty-ratio D.



VIII. INTERFACING OF PV MODULE WITH BUCK-BOOST CONVERTER

Fig-6 PV module with buck-boost converter

IX. SIMULATION RESULTS

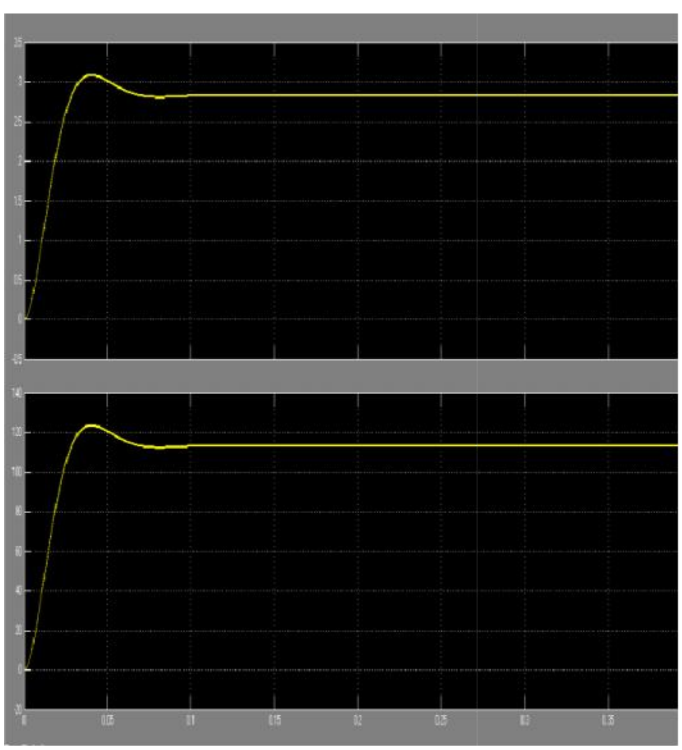


Fig-7 Waveforms of output current and output voltage

X. CONCLUSION

This paper is presenting the integrated circuit of the simulated PV module circuit with Buck-boost converter.This will help to understand the PV characteristics ,dc to d.c converter topologies,component calculation & circuit design.A step by step procedure of modelling a PV module is shown. in the simulation model. The curve between p-v & v-I is shown for varying temperature & varying irradiance. It was then interfaced with a buck-boost converter. The results obtained from the model show excellent correspondence to manufacturer's curve. This paper provides a clear & concise understanding of the I-V and P-V characterises of PV module which will serve as the model for researchers in the field of PVmodelling.

REFERENCES

(1) J.A. Ramos-HernanZ J.J. Campayo 1 J. Larranaga 2 E. Zulueta 3 O. Barambones 3 J. Motrico 1 U. Fernandez Gamiz 4 I. Zamora 1- TWO PHOTOVOLTAIC CELL SIMULATION MODELS IN MATLAB/SIMULINK.International Journal on "Technical and Physical Problems of Engineering" .

(2) Mathematical Modelingof Photovoltaic Module with Simulink.N. Pandiarajan and RanganathMuthu Department of Electrical & Electronics Engineering.International Conference on Electrical Energy Systems (ICEES 2011), 3-5 Jan 2011.

(3) Maximum Power Point Tracking For Photovoltaic System by Perturb and Observe Method Using Buck Boost Converter.M.S.Sivagamasundari1, Dr.P.Melba Mary2,V.K.Velvizhi3. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 6, June 2013.

(4) M. G. Villalva, J. R. Gazoli, E. Ruppert F, "Comprehensive approach to modeling and simulation of photovoltaic arrays", IEEE Transactions on Power Electronics, 2009 vol. 25, no. 5, pp. 1198--1208, ISSN 0885-8993.

(5) P. S. Revankar, W. Z. Gandhare and A. G. Thosar Government College of Engineering, Aurangabad, "Maximum Power Point Tracking for PV Systems Using MATLAB/SIMULINK", 2010 Second International Conference on Machine Learning and Computing.

(6) Hassan Abouobaida,MohamedCherkaoui, Department of Electrical Engineering, EcoleMohamediad'ingenieur, Mohamed V University, Rabat, Morocco, "Comparative Study of Maximum Power Point Trackers for Fast Changing Environmental Conditions". 978-1·4673-1520-3/12/ 2012 IEEE.

(7) A NEW APPROACH OF MODELLING, SIMULATION OF MPPT FOR PHOTOVOLTAICSYSTEM IN SIMULINK MODEL.M. Abdulkadir, A. S. Samosir, A. H. M. Yatim and S. T. Yusuf Department of Energy Conversion, Faculty of Electrical Engineering, Universiti y of Technology.

(8) Technical and Economic Modeling of the 2.5kW Grid-Tie Residential PhotovoltaicC. Chukwuka*, K.A. Folly*Department of Electrical Engineering, University of Cape Town System .INTERNATIONAL JOURNAL of RENEWABLE ENERGY RESEARCH K.A. Folly et al., Vol.3, No.2, 2013.

(9) G. Walker, “Evaluating MPPT Converter Topologies Using a Matlab PV Model”, Journal of Electrical and Electronics Engineering, Australia, Vol. 21, No. 1, pp. 49-56, 2001.

(10) M.G. Villalva, J.R. Gazoli, E. Ruppert “Modeling and Circuit Based Simulation of Photovoltaic Arrays”, Brazilian Journal of Power Electronics, Vol. 14, No. 1, pp. 35-45, 2009.

(11) J.A. Gow, C.D. Manning “Development of a Photovoltaic Array Model for Use in Power Electronics Simulation Studies”, IEE Proceedings on Electric Power Applications, Vol. 146, No. 2, pp. 193-200, March 1999.

(12) DEVELOPMENT OF A DC-DC BUCK BOOST CONVERTER USING FUZZY LOGIC CONTROL. FATHI SHABAN JABER.Faculty of Electrical and Electronic Engineering UniversitiTun Hussein Onn Malaysia M.sc Thesis.

(13) Muhammad H. Rashid, “Power Electronics Circuits, Devices and Applications”, Third Edition.

(14) I.H Atlas, A.M Sharaf, "A photovoltaic Array Simulation Model for Matlab- Simulink GUI Environment”, Proce. of IEEE International Conference on Clean Electrical Power, ICCEP 2007, Capri, Italy.

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