ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

PERFORMANCE OF MATHEMATICAL MODELING OF PHOTOVOLTAIC MODULE WITH SIMULINK BUCK-BOOST CONVERTER

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ABSTRACT

Photovoltaic systems require interfacing power converters between the PV arrays and the buck-boost converter. In this paper is proposes the modeling, design and simulation of photovoltaic solar cell model considering the effect of solar irradiations and changes temperature. Its voltage current and power voltage characteristics are simulated with different conditions. It is noticed that output characteristics of PV array are affected by environmental conditions and conversion efficiency is low. The use mathematical analysis is done for the single diode model. The single diode model is employed to investigate the I-V and P-V characteristics of 36 W module systems. The effect of irradiation and temperature is also considered. This mathematical analysis approach is a very flexible to change the parameters of the system.

KEYWORDS: Pv module, Solar cell, Boost, Buck, Buck-Boost Converter, etc.

INTRODUCTION

The solar energy conversion into electricity takes place in a semiconductor device that is called a solar cell. Ssolar cell is a unit that delivers only a certain amount of electrical power. The order to use solar electricity for practical devices, in which require a particular voltage or current for their operation, number of solar cells have to be connected together to form a solar panel, also called a photovoltaic (PV) module. For large-scale generation of solar electricity the solar panels are connected together into a solar array.

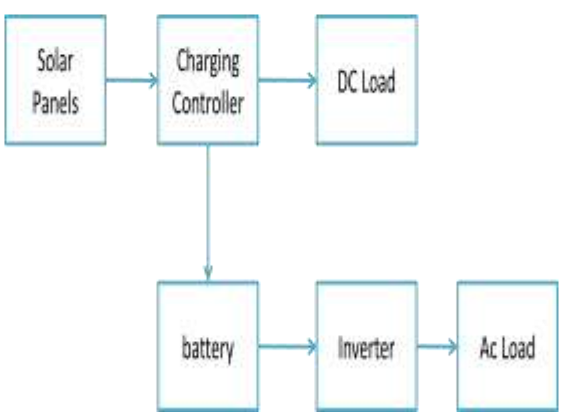

Fig: 1 Solar system module

PV module represents the fundamental power conversion unit of a PV generator. The output characteristics of a PV module depend on the solar in solution, the cell temperature and the output voltage of the PV module. Since PV module has nonlinear, it is necessary to model it for the design and simulation of maximum power point tracking (MPPT) for PV system applications.

Photovoltaic systems require interfacing power converters between the PV arrays and the grid. These power converters are used for two major condision. The first is to inject a sinusoidal current in to the grid. In second is to reduce the harmonics content in the grid injected voltage and current. There are two power converters system. The first one is a DC/DC power converter that is used to operate the PV arrays at the maximum power point supply. In the other one is a DC/AC power converter to interconnect the photovoltaic system to the grid system. Intensive efforts are being made to reduce the cost of photovoltaic cell production and improve efficiency and narrow the gap between photovoltaic and conventional power generation methods such as steam and gas turbine power generator. In order to decrease the cost of PV array production, and improve the efficiency of the system and collecting more energy for unit surface area different efforts have been made.

PHOTOVOLTAIC MODULE

A simple solar cell consist of solid state p-n junction fabricated from a semiconductor material. In dark, the IV characteristic of a solar cell has an exponential characteristic similar to that of a diode. However when the solar energy (photons) hits on the solar cell, energy greater than the band gap energy of the semiconductor, and release electrons from the atoms in the semiconductor, creating electron-hole pairs.

In this modeling the physical system is converted to computer codes and characteristics are plotted. To describe the behavior of the physical Photovoltaic (PV), and Photovoltaic (PV) model is chosen by the researchers. Ina most commonly used model is a single diode model.

The photovoltaic cell modeling was made possible by using equivalent circuits. There are two key parameters that are generally used to characterize a photovoltaic cell. The first parameter is called the short-circuit current (*Isc*) which is obtained by short-circuiting both terminals of the photovoltaic cell. In this case, the photovoltaic current is expected to reach its maximum value, while the voltage between the two terminals (*Vsc*) is zero. The second parameter is of great importance when it comes to a photovoltaic cell with two terminals that are not connected. In this case, the cell appears as an open circuit and the photovoltaic current is shunted within the cell by the intrinsic diode of the PN junction and the voltage across the cell reaches its maximum value called the open-circuit voltage (*Voc*), while the current in the external circuit is zero (*Ioc*= 0A). In the manufacturer of the photovoltaic module usually supplies these two parameters in the module's data sheet. The circuit consisting of an ideal current source connected in parallel with a diode, series resistor (*Rs*) and shunt resistor (*Rsh*).

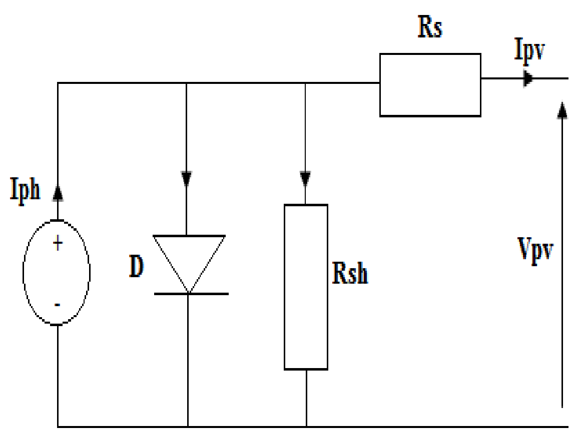

Fig: 2 Photovoltaic cell modeling as diode circuit

The current source Iph represents the cell photocurrent. Then the represents Rsh and Rs are the intrinsic shunt and series resistances of the cell, correspondingly. In usually the value of Rsh is very large and that of Rs is very small signal, hence they may be neglected to simplify the analysis. The photovoltaic (PV) cells are grouped in larger units called PV modules which are further interconnected in a parallel-series configuration to form PV arrays.

Modeling photo-current

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

Module reverse saturation current – Irs

$$I_{rs} = I_{SCr}/[\exp\left(\frac{qV_{oc}}{N_s kAT}\right) - 1] \quad (2)$$

The module saturation current I_0varies with the cell which is given by

$$I_0 = I_{rs}\left[\frac{T}{T_r}\right]^3 \exp\left[\frac{q*E_{g0}}{Bk}\left\{\frac{1}{T_r} - \frac{1}{T}\right\}\right] \quad (3)$$

$$I_{pv} = N_p * I_{ph} - N_p * I_0\left[\exp\left\{\frac{q*(V_{PV}+I_{PV}R_S)}{N_s kAT}\right\}\right] - 1 \quad (4)$$

Where Vpv = Voc, Np = 1 and Ns = 36

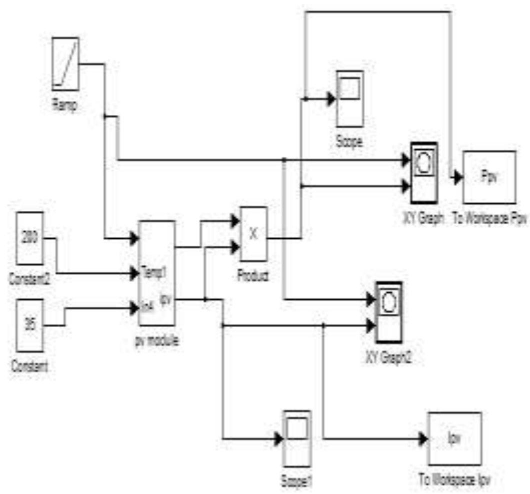

Fig: 3 Simulation pv model

Buck Converter Modeling

The buck converter with ideal switching devices will be considered here which is operating with the switching period of T and duty cycle D Fig. 4. The state equations corresponding to the converter in continuous conduction mode (CCM) can be easily understood by applying Kirchhoff's voltage law on the loop containing the inductor and Kirchhoff's current law on the node with the capacitor branch connected to it. The ideal switch is ON, the dynamics of the inductor current $i_L(t)$and the capacitor voltage $V_c(t)$are given by,

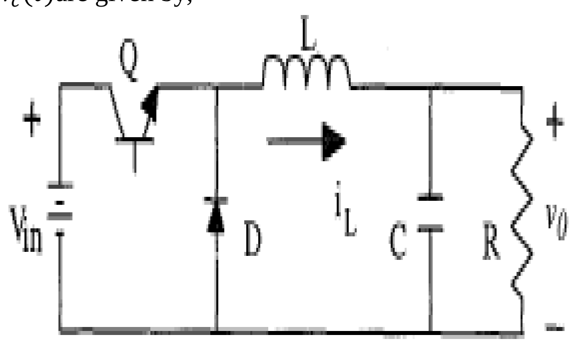

Fig: 4 Buck converter

Boost Converter Modeling

The boost is a popular non-isolated power stage topology, a sometimes called a step-up power. The power supply designers choose the boost power stage because the required output is always higher than the input voltage. The input current for a boost power stage is continuous power, and non-pulsating, because the output diode conducts only during a portion of the switching cycle. Output capacitor supplies the entire load current for the rest of the switching cycle. In the boost converter of Fig. 5 with a switching period of T and a duty cycle of D is given.

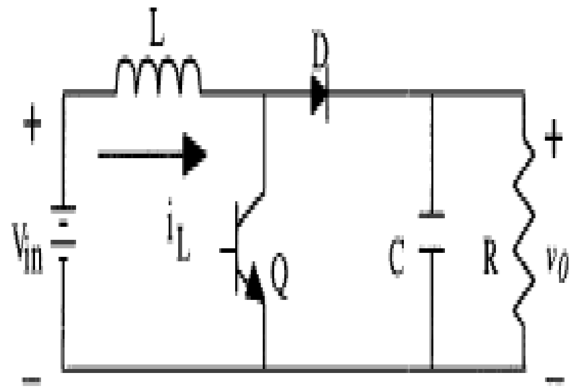

Fig: 5 Boost converter

Buck-Boost Converter Modeling

The buck–boost converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. In two different topologies are called buck–boost converter. Ina both of them can produce a range of output voltages, from an output voltage much larger (in absolute magnitude) than the input voltage, or down to almost zero. This is a switched-mode power supply with a similar circuit topology to the boost converter and the buck converter. Output voltage is of the opposite polarity than the input. The output voltage is adjustable based on the duty cycle of the switching transistor. The switching period is T and the duty cycle is D. in the assuming continuous conduction mode of operation, then the switch is ON, and the state space equations are given by,

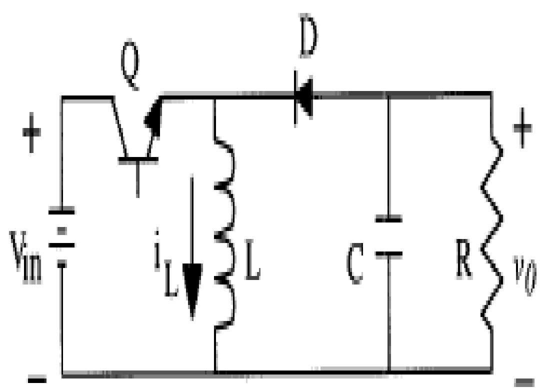

Fig: 6 Buck boost converter

RESULTS AND DISCUSSION

System description

The Figure 7 below shows the block diagram of the complete circuit. This includes the PV module, buck-boost converter and control circuit. The modeling and simulation of the whole system has been done in MATLAB-SIMULINK environment.

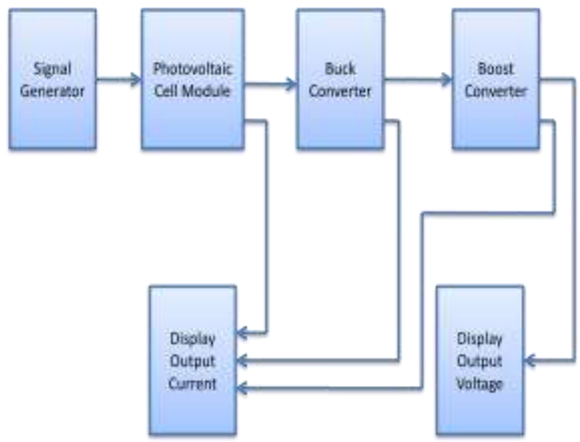

Fig: 7 System Block diagram of pv connected buck boost converter

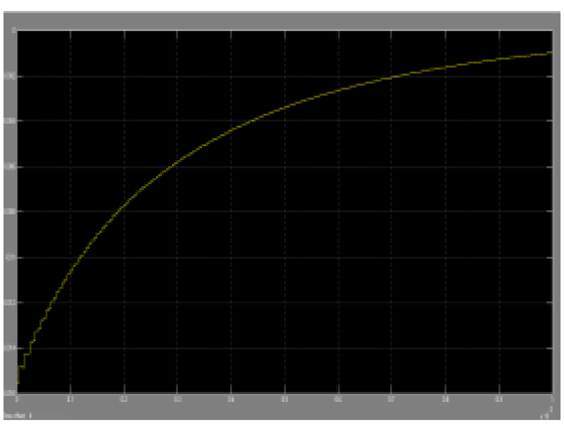

Fig: 8 Waveform of buck boost converter

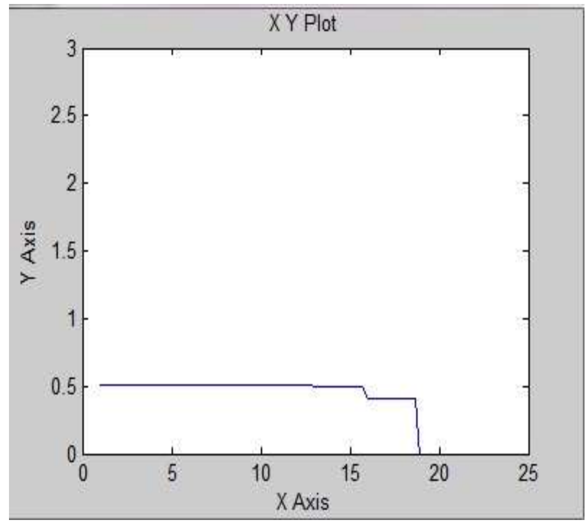

Fig: 9 Performance of Output –I-V Characteristics with varying irradiation

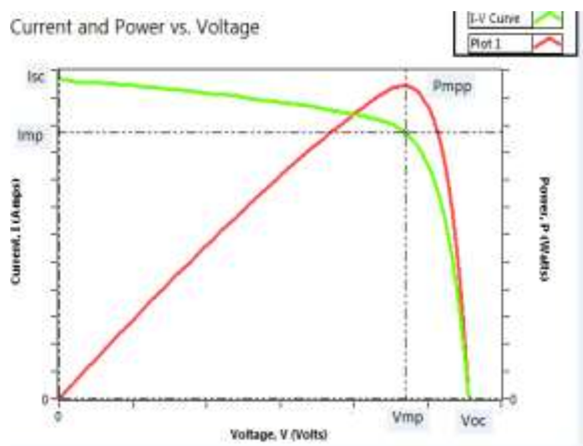

Fig: 10 Characteristic Current (I)-Voltage (V), Power (P)-Voltage (V) curve of a practical Photovoltaic cell

CONCLUSION

This paper is presenting the integrated circuit of the simulated PV module circuit with Buck-boost converter. A step by step procedure of modelling a PV module is shown. in the simulation model. This mathematical modeling procedure serves as an aid to induce more people into photovoltaic research and gain a closer understanding of I-V and P-V characteristics of PV module.

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