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To Perform Matlab Simulation of Battery Charging Using Solar Power With Maximum Power Point Tracking(MPPT)

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Abstract

Power from solar panel is affected by insolation and temperature variation which can be minimized by MPPT system. In this paper to extract maximum power from solar system, perturb and observe technique of MPPT is used. A PV system require proper battery charge controller to balance the power flow from PV system to battery and load such that photovoltaic power is utilized effectively. In this buck-boost regulator is used to controls the charging process of battery. MATLAB/Simulink model is used to analyze the converter, modal evaluation and parameter extraction.

Keywords: PV system, MPPT, converter, battery.

1. Introduction

The solar energy is the clean and sustainable energy, with long lifespan and a high reliability. To avoid losses of transmission and contributing reductions to CO_2 emission in urban centers, this system can be located in or near where the necessary takes place. A PV array consists of several photovoltaic cells in parallel and series connections. Parallel connection is responsible for increasing the current in the array whereas the series connections are responsible for increasing the voltage of the module. The obtained energy from the PV system depends on the voltage produced in the photovoltaic module, the temperature of the cell and the solar irradiation. There is no PV model to integrate with current electronics simulation technology in the Matlab/Simulink SimPowerSystem tool. Therefore it very difficult to analyze and simulate in the modeling of PV power system. In this research paper, PV system programming, perturb and observe MPPT technique, buck converter and battery (Li-ion) charging system is implemented.

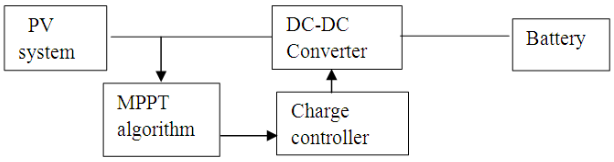

Fig. 1: Block diagram of system.

2. Photovoltaic Model

The equivalent circuit is shown in the Figure 1. Solar panel when exposed to the sun, a DC current is generated. The generated current varies linearly with the solar irradiance [1].

The equivalent electrical circuit of an ideal solar panel can be treated as a current source parallel with a diode as shown in Fig.2. There some losses exist in the real operation of the solar panel, to pick up these losses series resistance R_s and shunt resistance R_{sh} are added to the PV system.

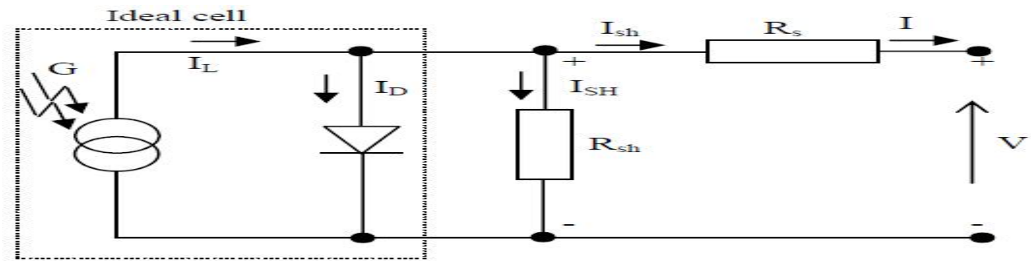

Fig.2: Equivalent circuit for PV system.

The electrical characteristic of solar cell used in the PN union is almost same as that of diode which is represented by the equation of Shockley (1) [2].

$$I_D = I_0(e^{\frac{V_c q}{akT_{cK}}} - 1) \quad (1)$$

Where:

I_D =Dark current(A).

I_0 =Saturation current of the diode (A).

q =Charge of electron, 1.6*10^{-19} (Coul).

V_c =Cell voltage (T).

T_{ck} =Cell temperature.

K= Boltzmann's constant, 1.38*10^{-23} (J/K).

a =diode ideality constant.

$$I = I_L - I_D \quad (2)$$

As shown in equation (2) the difference of the photocurrent I_L, (the current generated by the incident light, directly proportional to the sun irradiance) and I_D (the normal diode current) is the net current of the solar panel.

$$I = I_L - I_0(e^{\frac{(V+IR_S)q}{akT_{ck}}} - 1) \quad (3)$$

Equation (3) presents the net current of the solar panel of a simplified model.

$$I = I_L - I_0\left(e^{\frac{(V+IR_S)q}{akT_{ck}}} - 1\right) - \frac{V+IR_S}{R_{sh}} \tag{4}$$

Equation (4) represent the generated output current depends upon solar irradiance, voltage of the PV panel and ambient temperature.

3. Programming and simulation of the model.

3.1 PV programming.

This programming is based on the Matlab Software, which needs three values to calculate net current *I* of the [3,4,5].

- G (Sun) = Irradiance, 1 Suns = 1000 W/m^2.
- V_a = Operating voltage.
- T_aC = Temperature, in ^{o}C.

The program is divided into three parts:

1) Constant - Boltzan's constant, diode ideality factor, electron charge.
2) Variables – Calculation of I_L, I_0 and R_s are used.
3) Calculation of I_A.

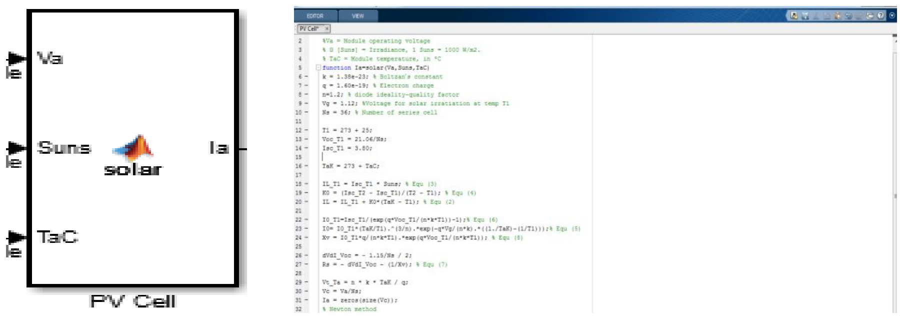

Fig. 3.1: (a) & (b) subsystem and programming of PV system.

3.2 Perturb and observe simulation

To draw maximum amount of power from the PV system, maximum power point tracking (MPPT) is necessary. Perturb and observe algorithm is very popular because of its ease of implementation and simplicity [6]. The module voltage is perturbed by a small increment, and the result change in power is observed. If the change in power positive, the voltage is adjusted by the same increment, and the power is again observed. This continues until the change in power is negative, at which point the direction of the change in voltage is reversed.

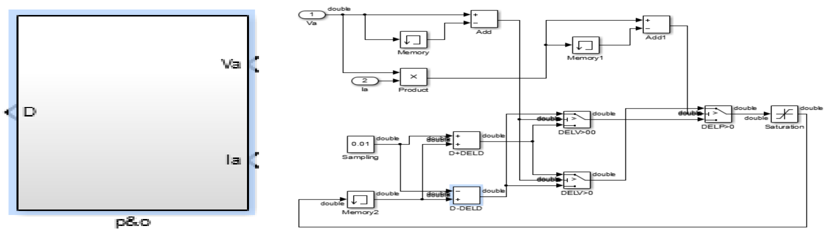

Fig. 3.2: (a) & (b) perturb and observe MPPT subsystem and simulink.

3.3 DC-DC buck/boost converter

A DC/DC converter consists of a number of storage elements and switches that are connected in a topology such that the periodic switching controls the dynamic transfer of power from the input to the output, in order to produce the desired DC conversion [7]. To obtain stable voltage from an input supply (Solar cell) that is higher and lower than the output, buck-boost converters are especially used. The purpose of the DC/DC converter is to transform a DC voltage from one level to another. This is done by varying the duty cycle, δ . The duty cycle is defined as the ratio of the "on" duration to the switching time period. For step down voltage buck converter, step up voltage boost converter are used.

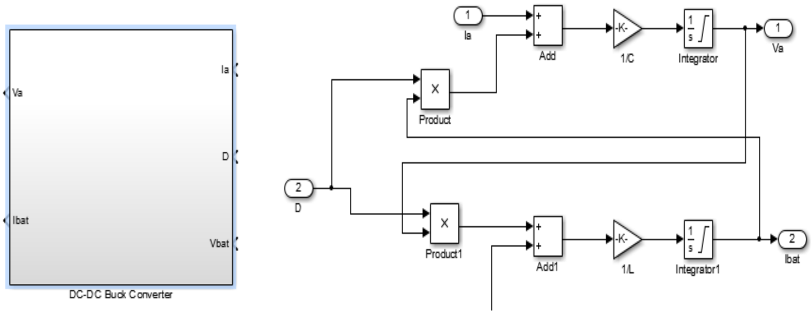

Fig. 3.3: DC-DC buck converter subsystem and Simulink..

3.4 Battery

Lithium-ion (Li-ion) battery has been widely adopted [8]. Li-ion batteries have several advantages compared to other rechargeable batteries, such as:

- Li-ion has higher energy density than most other types of rechargeable. This means that for their size or weight they can store more energy than other rechargeable batteries.
- It operate at higher voltages than other rechargeable, typically about 3.7V for lithium-ion vs. 1.2V for NiMH or NiCd. This means a single cell can often be used rather than multiple NiMH or NiCd cells.
- Li-ion batteries also have a lower self discharge rate than other types of rechargeable batteries. This means that once they are charged they will retain their charge for a longer time than other types of rechargeable batteries.

Li-ion batteries have some disadvantages compared to others, such as:

- Li-ion batteries are more expensive than similar capacity NiMH or NiCd batteries. This is because they are much more complex to manufacture. Li-ion batteries actually include special circuitry to protect the battery from damage due to overcharging or undercharging.
- Li-ion batteries also require sophisticated chargers that can carefully monitor the charge process.

4. Simulation Results

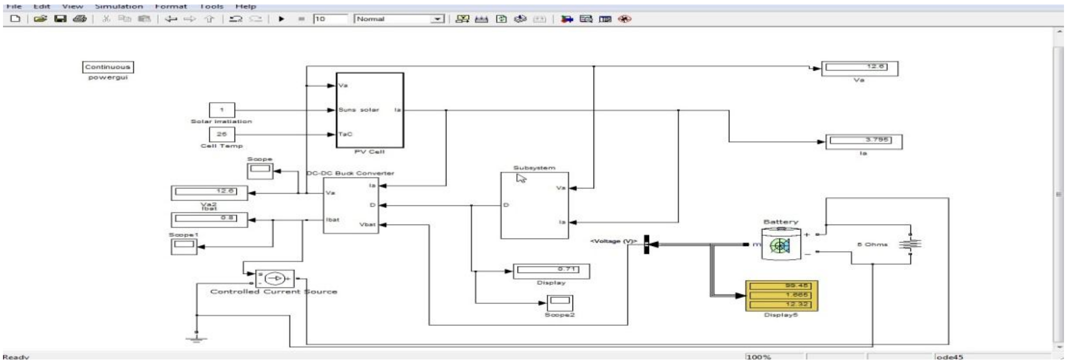

Fig.4.1: Simulation of Battery Charging using Solar Power with Maximum Power Point Tracking (MPPT).

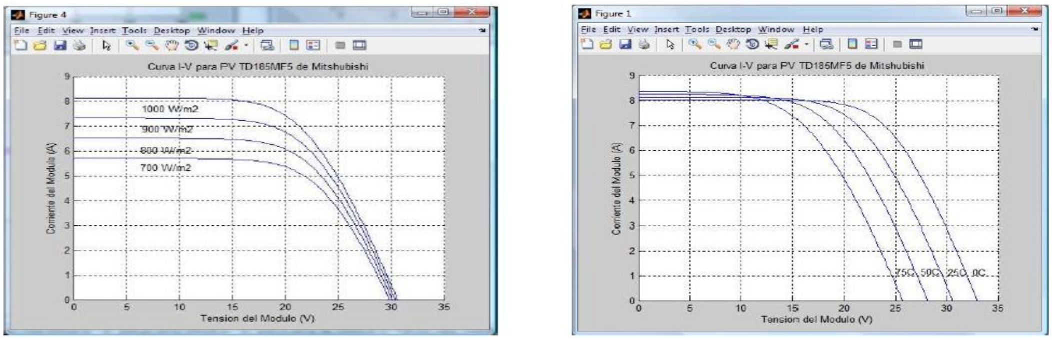

Fig.4.2: (a) & (b) Characteristic I-V for constant Temperature and constant Irradiance.

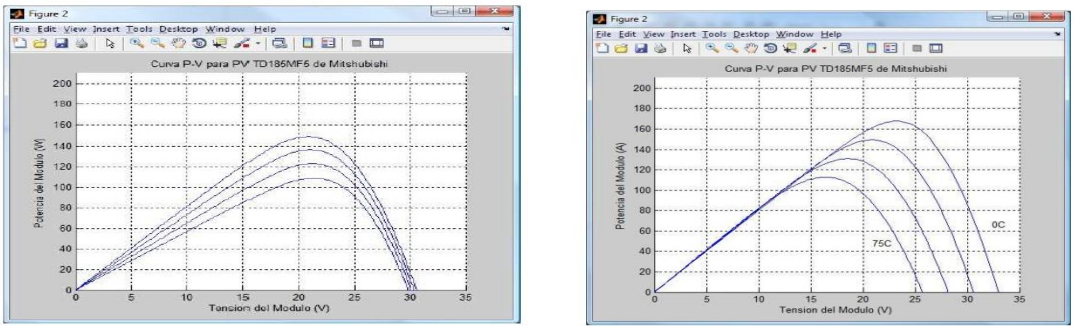

Fig.4.3: (a) & (b) Characteristic of P-V for constant Temperature and constant Irradiance.

5. Conclusion

The PV system in solar cell does not produce pollution, have no moving parts, and consume no fossil fuel during power generation. The present research paper describes the programming of the PV system and Matlab/Simulation of the Perturb and Observe technique of MPPT and DC-DC buck converter for charging the battery. This charged battery can be used at night, during rainy days and in winters. Therefore, it is our wish to make the PV system more efficient so that it can help for betterment of life.

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