Simulation and Analysis of Solar Cells based Boost Converter fed Electric Drives

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ABSTRACT

Background: Performance of Solar Cells. Objective: To develop IV and PV characteristic curves of photovoltaic modules. Results: The simulation of Solar Cells based Boost Converter fed Electric Drives in the balanced state. Conclusion: The effectiveness of the proposed system is verified through simulation using MATLAB Simulink. This paper presents the simulation of Solar Cells based Boost Converter fed Electric Drives using MATLAB Simulink. The mathematical model of Solar Cells are discussed and used for boost converter. The objective of this paper is to develop IV and PV characteristic curves of photovoltaic modules. The conceptual solution for proposed system is very challenge in high step-up renewable energy applications which are summarized to generate the next generation non-isolated high step-up DC/DC converters. The simulation results effectively controls the motor speed and enhances the drive performance.

INTRODUCTION

Nowadays power electronic devices contribute with an important role in all part of harmonics, such as power rectifiers, thyristor converters and static var compensators. It is predicted that by 2040 the emissions of carbon dioxide will more. So low carbon emission technologies will be of great importance. One of those is solar panels. The application of solar power drive is growing very high as they can offer clean source of energy. Photovoltaic sources play a significant role in the world energy portfolio and will become the biggest contributions to the electricity generation. Standard DC motors means a constant speed or adjustable speed motors. The control schemes are same day by day. For reliable operation various sources of electrical energy are employed along with the drive. The power control scheme uses semiconductor devices such as MOSFET, IGBT, etc. with various switching techniques. The designers are forced to optimization of the performance of solar power DC motor drives. The Fig.01 represents the basic block diagram of the proposed system. The physical principle behavior of solar cell is p-n junction of a semiconductor material sensitive to sunlight, i.e., the electrical behavior of a PV cell is same that as of a diode.

Fig.01: Block diagram of the system.

In our literature survey the PV arrays are still widely considered as an expensive choice compared with existing utility fossil fuel generated electricity which are discussed (Gow, J.A., C.D. Manning, 1999). In this paper author proposed a switching system that changes the cell array topology (Ramos, J.A., I. Zamora, 2010). The performance of a photovoltaic system has been discussed (Villalva, M.G., J.R. Gazoli, 2009). The system performance can be optimized by connecting the PV model with buck-boost converter (DeSoto, W., 2004). Different equivalent circuit models of PV cell have been discussed in literature (Walker, G., 2001; Rustemli, S., F. Dincer, 2011). Proper investigate how to get its maximum performance as possible (Kinal Kachhiya, Makarand Lokhande, 2011; Sojoudi, M., R. Madatov, 2011). From the above discussion it is clear that all
investigation are toward solar cell development. The proposed system trying to make PV equivalent module in MATLAB, which will represents a solar PV Module. The output of this is then provided to dc-dc boost converter for boost up the voltage from solar PV module. This Boost voltage is given to the DC motor for speed control.

**Analysis of Solar Cells and its Simulation:**

Solar cell can convert the energy of sunlight directly into electricity. The density of power which is radiated from the sun at the outer atmosphere is 1.373 kW/m2. The Final incident of sun light on the earth surface has the peak density of 1 kW/m2 at noon in the tropics. These Cells may be grouped to form panels. This panels can be grouped to form large solar cell arrays. The term array is usually employed to describe a solar cell panel or a group of panels. Most of time one are interested in modelling solar cell panels, which are the commercial solar cell devices. Fig.02 represents equivalent circuit of solar cell.

![Equivalent circuit of Solar cell](image)

Fig. 02: Equivalent circuit of Solar cell.

The output current of the solar cell, I is the difference of the solar cell short circuit current and the diodecurrent, assuming that the leakage current is negligible, Ish = 0, the current at the diode can be obtained by utilizing the following equation

\[ I_D = I_0(e^{V/V_T} - 1) \]  \hspace{1cm} (1)

Where "\( V/V_T \)" is the thermal potential and it is equal to KT/q and "K" is the BOLTZMAN constant, “q” is the chargeof an electron and “T” in °C is temperature, and "V" is the applied voltage.

\[ I = I_{SC} - I_D \]  \hspace{1cm} (2)

\[ I = I_{SC} - I_0(e^{V/V_T} - 1) \]  \hspace{1cm} (3)

The open circuit voltage occurs when I = 0 and therefore we obtain the following equations:

\[ I = 0 = I_{SC} - I_0(e^{V/V_T} - 1) \]

Solving for Voc yields:

\[ Voc = V_T \ln \left( 1 + \frac{I_{SC}}{I_0} \right) \]  \hspace{1cm} (4)

For an accurate modeling of the solar panel, two diode circuit could have been used, but our scope of study is limited to simple model. The following are the ideal characteristics of a solar array which show the variation of current and voltage with respect to voltage. Using MATLAB Simulink solar cell model is shown in Fig.03. The corresponding voltage waveform with respect to current and power is shown in Fig.04 and Fig.05.

The photovoltaic cell output voltage is basically a function of the photocurrent which is mainly determined by load current depending on the solar irradiation level during the operation. From the developed models, it is possible to study the behavior of photovoltaic cells in the time domain specification. The characteristic curve is, the relationship between the electric current (power) which provides the cell and the potential difference between its ends, for a given irradiation intensity, when the load is being varied.

**Analysis of boost converter fed electric drives:**

Converter-controlled electrical machine drives are very important in modern industrial applications. Some examples in the high-power range are metal rolling mills, cement mills, and gas line compressors. In the medium-power range are textile mills, paper mills, and subway car propulsion. Machine tools and computer peripherals are examples of converter-controlled electrical machine drive applications in the low-power range.
The converter normally provides a variable-voltage DC power source for a DC motor. The drive system efficiency is high because the converter operates in switching mode using power semiconductor devices. The primary control variable of the machine may be torque, speed, or position, or the converter can operate as a solid-state starter of the machine. The recent evolution of high-frequency power semiconductor devices and high-density and economical microelectronic chips, coupled with converter and control technology developments, is providing a tremendous boost in the applications of drives. The speed of a DC motor can be controlled by controlling the DC voltage across its armature terminals. The machine can be a permanent magnet or wound field type. The wound field type permits variation and reversal of field and is normally preferred in large power machines. In this paper boost converter is used to control the DC drive under no load and load conditions. The simulation of Boost converter fed DC drives is shown in Fig.06.

**Fig. 03:** Simulink model of Solar Cell.

**Fig. 04:** Current vs. Voltage waveform.

**Fig. 05:** Power vs. Voltage waveform.

**Fig. 06:** MATLAB model of Boost converter fed DC drives.
This approach is good for a low to medium power range. As the power level increases, the diode bridge begins to become an important part of the application. The Fig.07 shows the output voltage. The corresponding output voltage is boosted to 190 volts. The Fig.08 shows the pulse given to the semiconductor.

**Fig.07:** Output Voltage measures 190 volts.

**Fig.08:** Pulse across the semiconductor devices.

**Fig.09:** Speed of Motor at No-Load.

**Fig.10:** Speed of motor at $T=1 Nm$.

The drive is operated under two conditions. One at no load and another at loaded condition. The speed of armature is above 1000 rpm under no load condition and it gets reduced when it is operated at load condition. The results are shown in Fig.09 and Fig.10. The torque value is observed from Fig.11 and Fig.12. The speed torque curve of the DC motor is shown in Fig.13. The curve indicates that the speed decreases with increase in load torque. The load vs. speed curve is also shown in Fig.14.

**Conclusion:**

As a result of the study, a Matlab/SIMULINK model for the solar PV cell, modules and array was developed and presented in this paper. The output determines the quality of solar cell. The potential difference is measured at the end of solar cell. Boost Converter fed DC drive is modeled. This converter has advantages like high
performance. The speed torque curve indicates the mechanical characteristic of DC drive. Smooth speed control is possible with this converter. The simulation results are in line with the predictions.

Fig. 11: Torque at no load condition.

Fig. 12: Torque at TL=1 N-M load condition.

Fig. 13: Speed – Torque characteristics of motor.

Fig. 14: Load characteristics of motor.

REFERENCES


