BATTERY (Ni-Cd) CHARGING ANALYSIS OF STAND- ALONE 300W SOLAR PHOTOVOLTAIC SYSTEM AT CONSTANT SOLAR INSOLATION

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ABSTRACT

Efficient energy storage is proving to be one of the most imperial alternative from the solar photovoltaic system for power generation so far. Ni-Cd batteries is one of the widely acknowledged energy storage device that can line up with other charge storing devices. The solitary features of battery (nickel-cadmium) are such that it also praises other energy storage technologies. These batteries (Ni-Cd) have better performance characteristics than other conventional battery in the field of rapid charging and discharging capability, high power density and improved system efficiency. The very paper gives an insight the charging and discharging characteristics, voltage and current through load of constant solar insolation. The dynamic model of 300W stand-alone solar photovoltaic system with the very battery is simulated in matlab/Simulink environment.

Key words: Blocking/Bypass diode, insolation, solar cell model, SOC, stand-alone system

I. NTRODUCTION

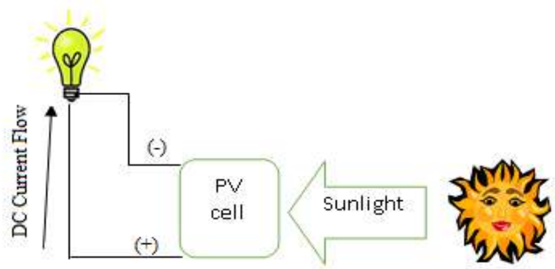
Energy is a decisive input for the industrial, social, and financial development and also plays a vital role in our life. Energy crises occur mainly due to two reasons first one rapidly increasing world population and later is higher living standard of human nowadays. If present trend continues, the world in the year 2000 A.D. will be more crowded than that of today. Thus, it is important to explore more and more alternative energy sources like sunlight, wind, and biomass and ocean energy. Photovoltaic energy are renewable, clean and eco-friendly energy source and it can be used as in various applications [1]. Solar energy is one of the most promising alternatives for conventional energy sources. Now a day's photovoltaic solar energy has been widely used to generate electricity [2-4]. Photovoltaic energy is emerging as an important distributed energy resource since few last decades [5]. However, these renewable energy sources reduce from some imperfection when they are used as a stand-alone energy sources. The naturally periodic properties of sun light causes power fluctuation on solar panel system. In addition it is difficult to store the power generated by solar panel for night and future use when sunlight is off [6-7]. Due to these reasons energy storage is required to maintain the power flow and also to manage systems momentary power balance. So for energy storage from solar panel mainly batteries or super capacitor are Used. This paper is further organizes as follows. Section II describes the photovoltaic cell. Section III explain the modeling and simulation of solar PV system. In this section solar cell modeling and battery modeling is describes. Section IV describes the case study and the result and analysis after successful simulation of proposed 300 W stand-alone solar photovoltaic system. While conclusion are presented in section V.

II. DESCRIPTION OF PHOTOVOLTAIC CELL

Solar cell is a device that converts the energy of sunlight directly into electricity by the photovoltaic effect [8]. The photovoltaic effect can be described the light, which is in the form of energy, strikes a PV cell and transfers enough energy to cause the freeing of electrons. A built-in potential barrier in the cell acts on these electrons to produce a voltage which can be used to drive a current through an electric circuit .The basic material for the photovoltaic cells is high purified silicon (Si), which is obtained from sand or quartz. Photovoltaic cell are of mainly three type's monocrystalline silicon cell, polycrystalline silicon cell, amorphous silicon cell. Photovoltaic cells are semiconductors that have weakly bonded electrons at a level of energy called valence band [9-10]. When energy strikes at the valance bond it release, that electrons and that electrons moves to another energy level known as conduction band. At the conduction band, the electrons are able to conduct electricity through an electrical load. Fig.1 shows the simple concept of photovoltaic system. PV cells use the energy of photons from sunlight to break their band gap energy thereby producing DC current. Typically, PV cells produce low power (approximately 2-
3Watts) [11] hence to develop more power, voltage multiple solar cell need to be connected in series or parallel and overall meeting is known is module. Within a module the different cells are connected electrically in series or in parallel although most modules have a series connection. Individual cells are usually connected into a series string of cells (typically 36 or 72) to achieve the desired output voltage. In a series connection the same current flows through all the cells and the voltage at the module terminals is the sum of the individual voltages of each cell. When modules are connected in parallel the current will be the sum of the individual cell currents and the output voltage will equal that of a single cell. The nominal voltage of a solar module is 12V and a PV module for charging 12V batteries usually has 33 to 36 cells. Several module are connected in series, parallel, series-parallel configuration to form an array. Photovoltaic (PV) systems are of a modular nature [12].because Solar cells can be connected in series or parallel in virtually any number and combination. Therefore, PV systems may be realized in an extraordinary broad range of power; from mille watt systems in watches or calculators to megawatt systems for central power production.

III. MODELING & SIMULATION OF SOLAR (PV) SYSTEM

The single line diagram of proposed 300W stand-alone solar photovoltaic (PV) system is given in fig.2 it consist of a battery storage unit, an inverter, blocking and bypass diode and a charge controller.



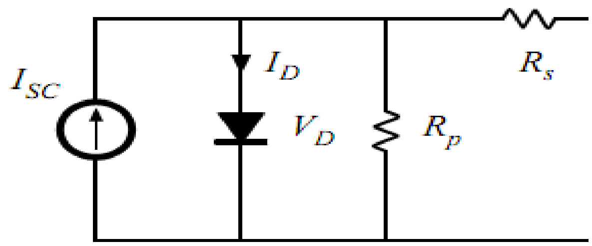


Fig.1. Concept of Photovoltaic **Fig.3. Single exponential model of PV Cell**

3.1 PV Cell Model

Many equivalent circuits have been proposed in the literature [13-16] in order to assess the behavior of the PV cell. The mathematical model of PV cell is represented by a current source with a diode connected in parallel as shown in fig.3. This model has current constant source (I_{SC}), connected with a diode a series resistance (R_s). The modeling of the standalone solar PV system is based on the equivalent circuit diagram of the PV cell. Functional block parameters which are used in PV cell model can be shown in table 1. Applying Kirchhoff's law to the node where ISC, diode, RP and RS meet, we get the following equation for the photovoltaic current.

On applying the KCL

$$I_{SC} - I_D - \frac{V_D}{R_P} - I_{PV} = 0 \quad (1)$$

Diode Current

$$I_D = I_O(eV_D/V_T \ -1) \quad (2)$$

On applying the KVL

$$V_{PV\ Cell} = V_D - R_S \cdot I_{PV} \quad (3)$$

Parameters	Rating
Short-circuit current	7.97
Short-circuit voltage	22.1
Current at P_{max}	7.46
Voltage at P_{max}	18.19

Table.1 Parameters of Battery

3.2 Battery Model

Batteries are the central part of the any stand-alone PV system. The battery block implements a generic dynamic model parameterized to represent most popular types of rechargeable batteries.

Discharge model (i*>0)

$$f_1(it\ ,i*i,Exp) = E_o - K\cdot\frac{Q}{Q-it}\cdot i* - K\cdot\frac{Q}{Q-it}\cdot it + Laplace^{-1}\left(\frac{Exp(s)}{Sel(s)}\cdot 0\right) \tag{4}$$

Charge model (i*<0)

$$f_2(it, i*, i, Exp) = E_o - K\cdot\frac{Q}{it+0.1\cdot Q}\cdot i* - K\cdot\frac{Q}{Q-it}\cdot it + Laplace^{-1}\left(\frac{Exp(s)}{Sel(s)}\cdot\frac{1}{s}\right) \tag{5}$$

Table 2 shows block parameter used to modify the battery specifications for the modelling.

Table.2 Parameters of Battery

Parameters	Rating
Nominal voltage (V)	24
Rated capacity (AH)	165
Initial state-of-charge (%)	20
Maximum capacity (AH)	171.85
Fully charged voltage (V)	26.1316

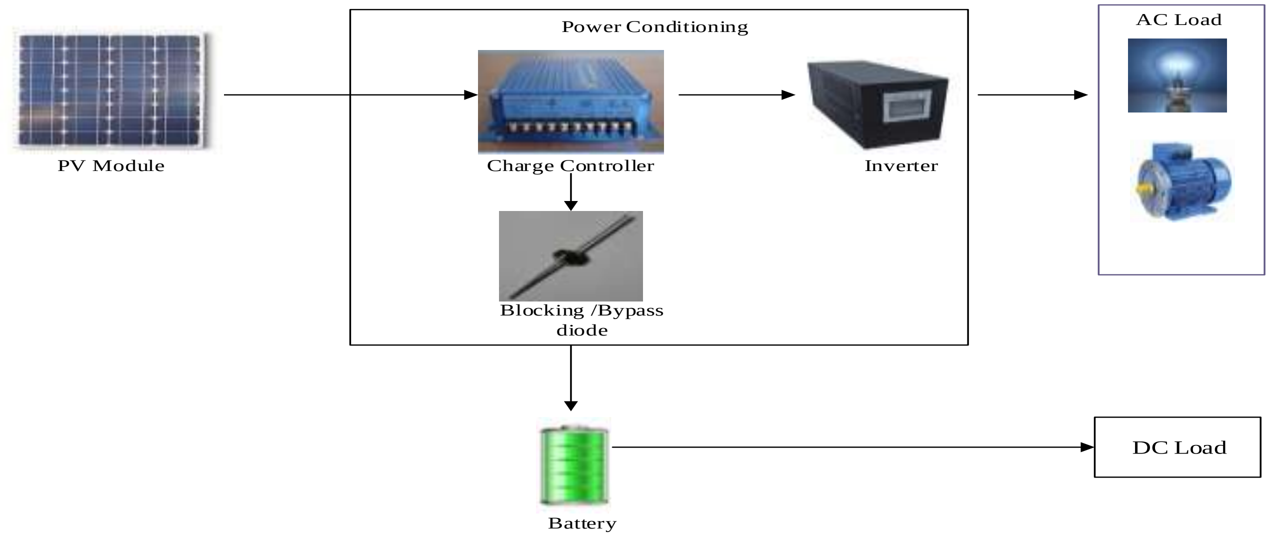


Fig.2. Single Line Diagram of 300W Stand-alone Solar PV System designed in Simulink/Simpower system

IV. SIMULATION RESULT AND ANALYSIS

In this section the simulation result of proposed model is discussed. Such as result has also allowed the validation of proposed model. In this paper, the simulation result obtained during constant solar insolation. The proposed model consists of resistive + Inductive (2+j0.01) Ω type load. During simulation the parameters values that are used to represent a battery, can be used as default values. The Simulink model shown in fig.2 are simulated and observed output waveform are shown in fig.4.and fig.5. It produces an output power of 271.49 W for a constant radiation of 1000 W/m^2 and output voltage 36.23 V.Fig.6 shows the battery output voltage, output current and %SOC and output voltage and output current of 300W solar PV system through load (Resistive Inductive) for battery is shown in fig.7. The Charging and discharging cycle are confronted to the one provided by the model. The cycle are displayed in fig.4 are simulated for 100*2000 sec.at constant moments of the day. The number of cycles increases with the insolation as the photovoltaic electricity production gets higher. We can see that the shape of the voltage during charging and discharging is well reproduced by the simulation. At constant solar insolation 1000 W/m2 battery take 12.31 hours becoming full charge.

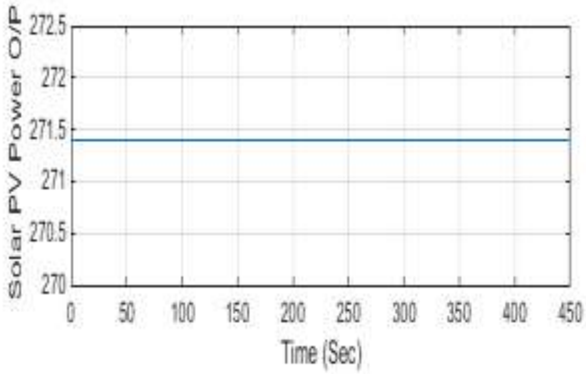


Fig.4. Solar PV Output Power

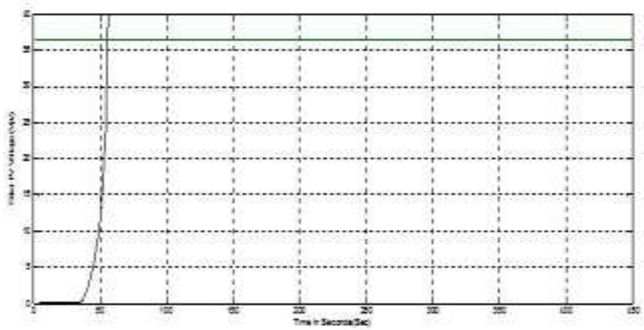


Fig.5. Solar PV Output Voltage

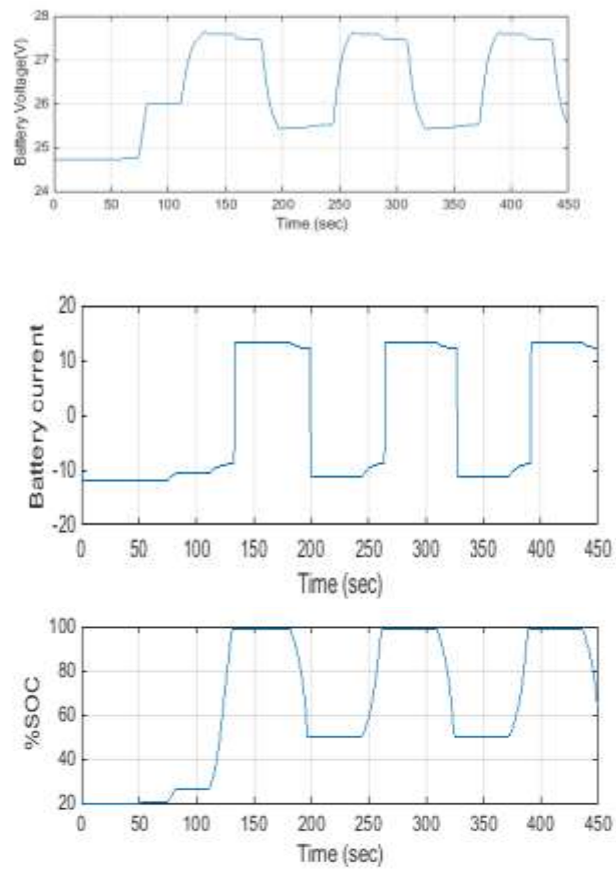


Fig.6. Output current, voltage and state of charge of battery for initial charging-discharging time

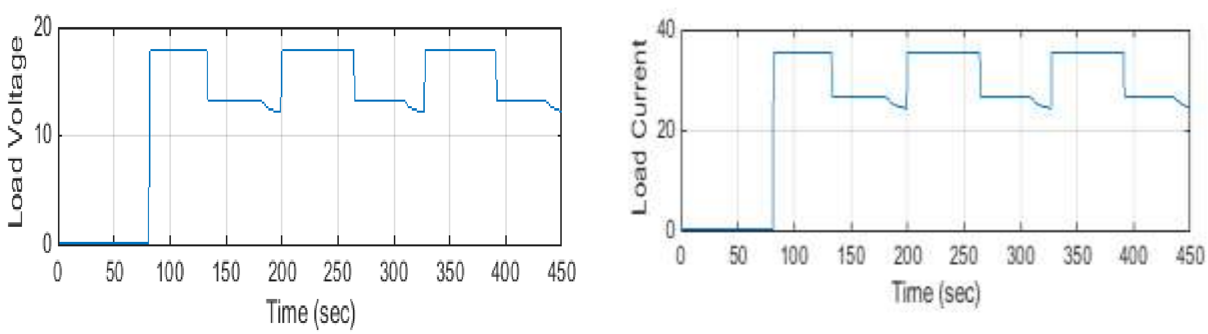


Fig.7. Output voltage and current through load for initial SOC of battery

V. CONCLUSION

The most prevailing agony in today's world power market is the shortage of fossils fuel. The planet is progressively marching toward a satirical state of energy crises, owing to an escalating energy utilization which is far greater than its supply. And the shortage of fossil fuel is providing the necessary nourishment for this mushrooming problem. Hence the necessity to explore more and more alternative energy sources has become a matter of utter significance but more important is to store that energy in appropriate device. Based upon the result discussed above, we can say that these nickel Cadmium battery is better in comparison with other conventional battery as general solution for power storage. What makes these batteries to stand a cut above other battery is its durability and flexibility that can be adopted to serve in many roles for which conventional batteries are not as well suited. It also consists high power density. The charging and discharging time of Ni-Cd battery is also less in comparison with other conventional battery. By the end of this century, nearly all of the economically available energy resources will be gone. From now until then, what remains will be rationed by price. Thus these storage device may emerge as a boon for many application of power system in terms of efficiency.

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