

# EXPERIMENTAL VALIDATION OF SOLAR WATER PUMPING SYSTEM USE FOR AGRICULTURE

## PURPOSE

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### ABSTRACT

*This paper presents the modeling & simulation of photovoltaic model with DC-DC converter motor model using MATLAB/simulink. This model design is user friendly using simulink block libraries in MATLAB software. There are various parameters which effect of the solar PV panel like as, irradiance & temperature, humidity, air flow into considering the output circuit and power characteristics of PV panel are simulated & DC-Dc converter & motor is connected to the PV model. The proposed model is applying 100W PV modules; the proposed model is affected the variation in irradiance & temperature variation.*

***Keywords: solar pv cell, matlab simulation, water pumping system.***

### I. INTRODUCTION

Solar energy is source of heat energy, they are the many technologies are involving such as solar heating, photovoltaic solar thermal energy. The solar energy architecture is depending on the photo electric effect. The solar energy is regenerative energy & this energy characterized as active or solar depending on the way the solar energy is convert the solar power. Photovoltaic system has the many applications solar energy is widely used in island & hilly areas. There are various environmental parameter which are affected on the efficiency of solar pv panel. The major parameter is the temperature which is greatly affected on the PV panel. When temperature increases the efficiency of the panel decreases. Lower temperature is efficient to increase the efficiency of solar panel. Simulator of solar panel in MATLAB simulink. The design of water pumping system in MATLAB simulink. By using standard equation design the PV panel. Pv panel is connected to the buck-boost converter with mppt. mppt is maximum power point tracker mppt is kept the output voltage remains constant & increases the efficiency of the Output voltage of solar pv panel. dc motor is connected to the mppt controller & characteristics of the motor is varied according to the environmental parameter. MATLAB simulation provides many facilities for determining locating & calculating different parameters which are affected parameters which are affected according with atmospheric condition & can store the data according to the time variation.

The model is prediction of PV cell behave or under various atmospheric condition. MATLAB simulation has been done to calculate voltage at maximum  $V_m$ ,  $P_m$ . The system has MPPT to compare the actual irradiance data & compare the maximum output power of the PV panel. The performance of solar water pumping system is

discussed in this paper. PV array of dc motor, MPPT and the diaphragm pump. If the change in the solar temperature and irradiance data the MPPT track the maximum power output and takes the output power constant and gets the maximum efficiency.

**II. EXPERIMENTAL SET-UP AND DESCRIPTION**

**SOLAR CELL WORKING**

Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, the some of the photons of light ray are absorbed by the semiconductor crystal which causes significant number of free electrons in the crystal. This is the basic reason of producing electricity due to photovoltaic effect. Photovoltaic cell is the basic unit of the system where photovoltaic effect is utilized to produce electricity from light energy. Silicon is the most widely used semiconductor material for constructing photovoltaic cell. The silicon atom has four valence electrons. In a there is plenty of free electrons which are negatively charged by nature. When instead of pentavalent phosphorous atoms, trivalent impurity atoms like boron are added to a semiconductor crystal totally opposite type of semiconductor will be created. In n-type semiconductor mainly the free electrons carry negative charge and in p-type semiconductor mainly the holes in turn carry positive charge therefore free electrons in n-type semiconductor and free holes in p-type semiconductor are called majority carrier in n-type semiconductor and p-type semiconductor respectively.

There is always a potential barrier between n-type and p-type material. This potential barrier is essential for working of a photovoltaic or solar cell. While n-type semiconductor and p-type semiconductor contact each other, the free electrons near to the contact surface of n-type semiconductor get plenty of adjacent holes of p-type material. Hence free electrons in n type semiconductor near to its contact surface jump to the adjacent holes of p-type material to recombine.

**III. MATERIALS AND METHODS**

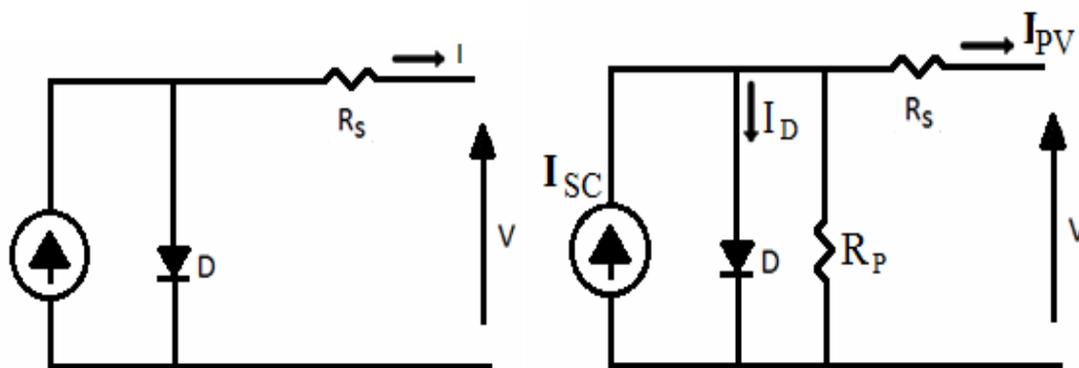


Fig.1.1: solar cell model using single diode Fig.1.2:solar cell model using single diode with  $R_s$  &  $R_p$

The light current depends on both irradiance and temperature. It is measured at some reference condition.

Thus

$$I_{sc} = [(I_{scref} + K_i (T_k - T_{ref}))] \tag{3}$$

Where  $I_{sc}$  is the photocurrent (A) which is the light generated current at the nominal condition ( $25^{\circ}C$  and  $1000W/m^2$ ),  $K_1$  is the short circuit current and the temperature coefficient at  $I_{sc}$ ,  $T_k$  &  $T_{ref}$  are the actual and reference temperature. A more practical model is shown in fig 2

Where  $R_p$  &  $R_s$  represent series and practical resistance respectively.

Where  $K$  is the Boltzmann constant ( $1.38 * 10^{-23}JK^{-1}$ )  $T$  is the cell temperature (K);  $N_s$  is the number of cells connected in series = 36.  $N_p$  is the number of cells connected in parallel = 1,  $V_{pv} = V_{dc} = 21.06$  V. the non linear & implicit equation (4) depend on the incident solar irradiance, the cell temperatures and on the reference values.

$$I_{sc} - I_d - V_d/R_p - I_{pv} = 0 \quad (4)$$

$$I_{pv} = I_{sc} - I_d - V_d/R_p \quad (5)$$

And the reverse saturation current  $I_{rs}$  is given by;

$$I_{rs} = I_{sc,ref} [\exp(qV_{oc}/N_sKAT) - 1] \quad (6)$$

The module saturation current  $I_0$  varies with the cell temperature which is given by

$$I_0 = I_{rs} [(T/T_{ref})^{3eq9/AK} * (1/T_{ref} - 1/T)] \quad (7)$$

Where  $I_0$  is the diode saturation current (A). The basic equation and describes the current output of the photovoltaic (PV) module  $I_{pv}$ . Of single – diode model equation is as given in,

$$I_{pv} = N_p I_{sc} - N_s I_0 [\exp(q(V_{pv} + I_{pv}R_s/N_sAKT) - 1) - V_{pv} + (I_{pv}R_s/R_p)] \quad (8)$$

Thus, Where is the photocurrent in (A) which is the light-generated current at the nominal condition ( $25^{\circ}C$  and  $1000W/m^2$ ),  $K_i$  is the short-circuit current/temperature coefficient at ( $0.0017A/K$ ), and are the actual and reference temperature in K, is the irradiation on the device surface, and  $1000W/m^2$  is the nominal irradiation does not adequately represent the behavior of the cell when subjected to environmental variations, especially at low voltage A more practical model is shown in Figure-1.1, where and representing series and parallel resistance, respectively.

In this propose model, a current source which depends on solar radiation and cell temperature; a diode in which the inverse saturation current depends mainly on the operating temperature; a series resistance and a shunt resistance which takes into account the resistive losses.

Figure-1.1. Solar cell model using single diode.

Thus, and the reverse saturation current is given as: The module saturation current varies with the cell temperature which is given by; Where is the diode saturation current (A). The basic equation that describes the current output of the photovoltaic (PV) module of the single-diode model is as given in equation.

Mathematical model for a photovoltaic cell

Fig.1 are models of the most commonly-used PV cell: a current source parallel with one or two diodes.

A single-diode model has four components: photo-current source, diode parallel to

Source, series of resistor  $R_s$ , and shunt resistor  $R_{sh}$ . Fig.1 (b) is a two-diode model: the extra diode is for better curve-fitting.

PV module represents the fundamental power conversion unit of a photovoltaic system. The output characteristics of PV module depend on the solar radiation, cell temperature

And output voltage of PV module. Since a PV module has nonlinear characteristics, it is necessary to model it for the design and simulation of a maximum power point tracking (MPPT) for PV system applications. In order to get a maximum output.

Power from the solar cell, a maximum power point tracker system is highly recommended. The output power delivered by a PV module can be maximized using MPPT control system. It consists of a power conditioner to interface the PV output to the load, and a control unit, which drives the power conditioner for extracting the maximum power from pv array.

Cell temperature is 25degree C. Real operating conditions are always different from the standard conditions, and mismatch effects can also affect the real values of these Meantoparameters.The use of the simplified circuit model for this work makes it suitable for power electronics designers to have an easy and effective model for the simulation of Photovoltaic devices with power converters. The value of the parallel resistance is generally high and hence neglected to simplify the model a procedure based on Simulink model to determine the values to these parameters is proposed. The evaluation of these model parameters at real condition of irradiance and temperature of the target PV modules are then determined according to their initial values.

### SIMULINK MODELLING OF PV MODULE

The detailed steps to this procedure for the Simulink model are given in the next section. Simulink modeling of a pv panel MXS 60 PV Module is taken as the reference module for simulation and the data sheet details are given in Table-1. A block diagram of the stage by stage model based upon the equations of PV model is represented in Simulink environment as given in Figures 3 to 9. These models are developed in moderate complexity to include the temperature dependence of the photo current source, the saturation current through the diode, and a series resistance is considered based upon the shackle diode. Since the main objective is to develop a functional PV model for the Simulink environment, the system is modeled to supply power to the load.

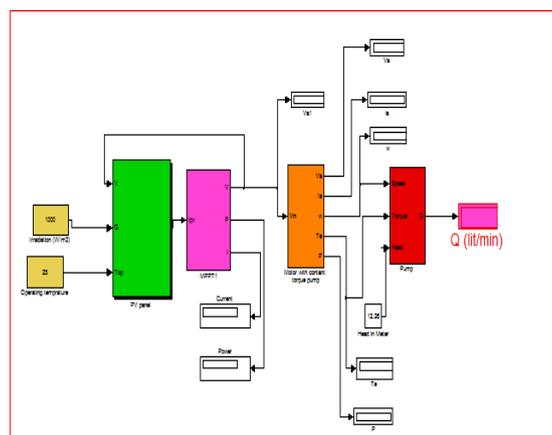


Fig.1.3

### Modeling of Maximum Power Point tracking system

Since the output of the PV is less efficient, a MPPT system is adopted to enhance the PV power. This is achieved by varying the duty cycle of the buck boost converter so that the source impedance can be matched with load impedance. Each time the output power of the buck boost converter is compared with the previous power of the module and the duty cycle of the converter is adjusted accordingly to track maximum power point. This process continues until the power of the PV reaches the maximum value.

**A. Perturb and Observe method:**

In this algorithm, the PV voltage  $V(k)$  and the current  $I(k)$  are the inputs. The power of the PV is calculated accordingly. The power and the voltage of the PV are delayed by  $(k-1)$  instant. The present value of  $P$  and  $V$  are compared with the previous values and their difference is noted.  $\Delta P = P(k) - P(k-1)$   $\Delta V = V(k) - V(k-1)$  If  $\Delta P$  and  $\Delta V$  are positive then the duty cycle is decreased i.e.;  $D = D - \Delta D$ . And if  $\Delta P$  is positive and  $\Delta V$  is negative duty cycle is increased i.e.;  $D = D + \Delta D$ . On doing this repeatedly, the maximum power point is tracked and the output power of the PV system is maximized.

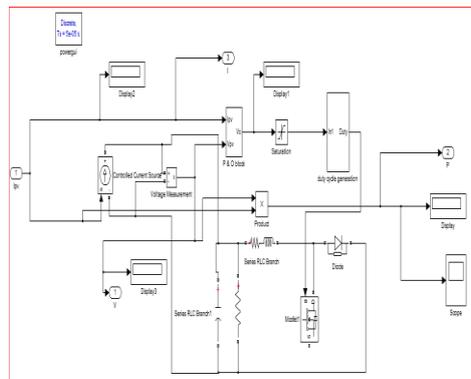


Fig.1.4

The duty cycle is generated by the MPPT system and it is compared with a repeating sequence to produce a PWM signal as shown in the figure. The PWM signal is used to control the ON and OFF time of the IGBT in the converter. As long as the IGBT is ON, the capacitor charges and the input voltage of the converter i.e. the PV voltage is reproduced at the output. If the duty cycle  $D > 0.5$  then the output voltage of the converter is larger than the input voltage and if  $D < 0.5$  the output voltage is smaller than the input voltage.

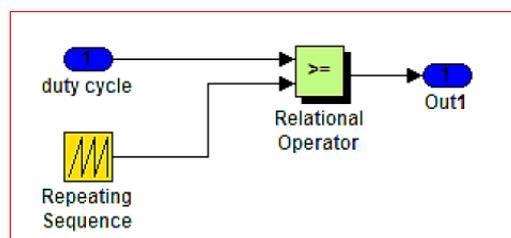


Fig.1.5

**Modeling of Dc shunt Motor-**

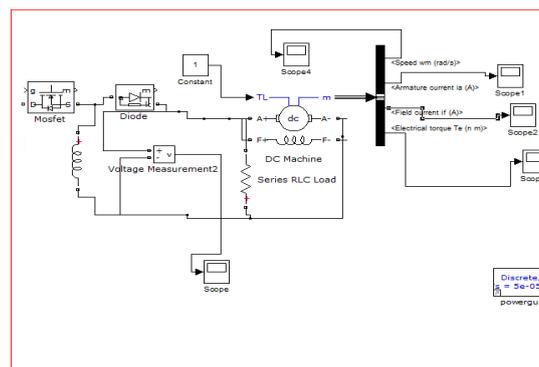


Fig.1.6

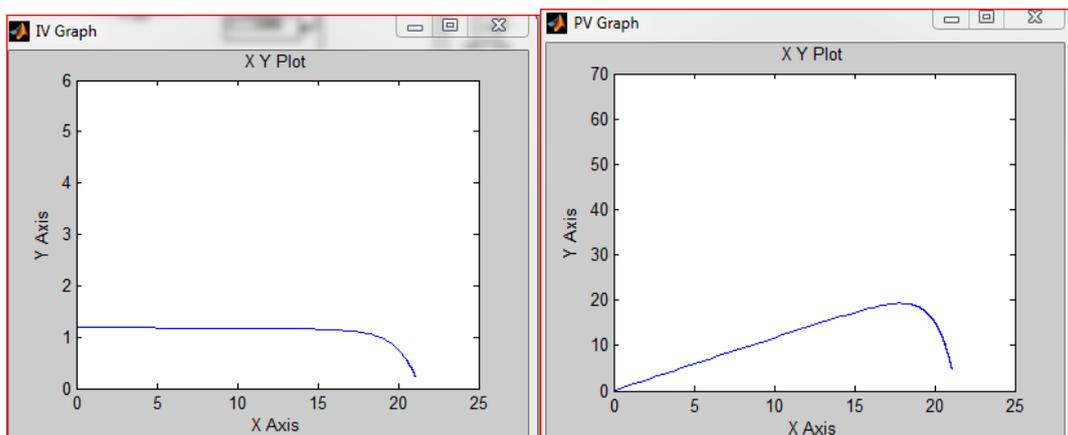
The output of the MPPT is giving to Motor.MPPT track a maximum power track and output is constant at a point and efficiency increase.PV panel is simulated and DC to DC converter is connected to the PV model.

#### IV.THE SIMULATION RESULTS

The model of the PV module was implemented using a Matlab Simulink model. The PV module chosen for this simulation is MXS60, which provides 100W nominal maximum power and has 36 series connected cells the parameter specification of the module is as shown in Table-1. The model was built in stages as indicated above starting from stage A to the final model. The subsystem contains all the mathematical equations of every stage model block. Figure-10 shows the I-V output characteristics of PV module with varying irradiance at the constant temperatures.

It is depicted that the PV output current varies drastically with insulation conditions and there is an optimum operating point such that the PV system delivers its maximum possible power to the load. The optimum operating points changes with the solar insulation, temperature and load conditions. The P-V out characteristics of the PV module with varying irradiance at the constant temperature from the graphs when the irradiance increases, the current and voltage output also increases. This result shows the net increase in power output with an increase in irradiance at the constant temperatures. Furthermore, it is well known that for a certain PV panel, the voltage-power characteristics are fixed for each isolation without intersection. Hence, for any given PV voltage and power, the corresponding isolation can be estimated. The I-V and P-V characteristics under constant irradiance with varying temperature are presented in Figure 12 and 13, respectively. When the operating temperature increases, the current output increases marginally but the voltage output decreases drastically, which result in net reduction in power output with a rise in temperature.

Solar water pumps can provide simple and labor watering option for farms that required water in remote areas. Water storage in metal or plastic tanks is used instead of power storage battery. These reduce cost and system make simpler. In MATLAB software we studied various parameters affecting on the efficiency of PV cell is a temperature, humidity, air flow, and irradiation. Sunlight is the source if electricity but thermal heat is required to generate in PV system. A basic need of this project is in remote areas where electricity is not reaches in rural areas.





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