

Simulation and Analysis of Photovoltaic Solar System for different Weather Condition in Anand

Sachin Patel¹, Kaushal Shah²

^{1,2}Assistant Professor, Electrical Department, G H Patel College of Eng. & Technology, V V Nagar, India

Abstract - This paper presents the whole design and simulation of single phase Photo voltaic inverter connected load for converting the energy extracted by the PV arrays to AC power to be utilized in standalone applications without batteries storage. The proposed model consists of two stages. The first stage is a DC-DC boost converter. It is accountable to control and boost the DC output voltage of the PV system. The second stage of the model is a full bridge DC-AC inverter that converts the regulated DC output voltage of the boost converter to AC voltage. The designed system has been tested using MATLAB simulation at different load and weather conditions and capable for converting the PV system DC voltage level to AC output voltage.

Key Words: Photovoltaic System, DC-DC boost converter, Full bridge inverter, load.

1. INTRODUCTION

Solar Energy is an important of the renewable energy in the world, but some factor has limited its general use and adoption. The major problem is the relatively costlier installation of PV array. That has reduced it uncompetitive in the power market. So more research is needed into making solar cheaper modelling and simulation of PV arrays is done to estimate its characteristics better and extract maximum power from the PV system. The basic objective would be to study PV system observing the battery characteristics and successfully implementing controlled grid connected inverter to the PV system using Simulink models.

The world trends now a day to use the photovoltaic systems as distributed generator for being environmentally friendly, renewable, and a significant descent was seen in the price of the PV panels. Also PV panels do not include moving portions, therefore; a long lifetime is guaranteed with a very simple maintenance [2]. In recent years, large numbers of projects are aimed to make utilize of the energy generated by PV systems as a reserve sources to support the existent utility grid or used as standalone system. Power inverters are required to convert the DC power from the PV panels (or arrays) and feed to the AC load. They scout about producing sinusoidal output current that meet the required standards.

2. DESCRIPTION OF THE SYSTEM

PV Cell Modeling

Photo voltaic cell works on the principle of photoelectric effect. It is defined as a phenomenon where sunlight of certain wavelength is absorbed by a matter leading to movement of an electron from its conduction band. In PV cell, when light is absorbed by the p-n junction, the energy of the absorbed by the photon, and it is transferred to the electron system of the material. These result in the charge carrier generation which was separated at the junction. These charge carriers at the junction region are electron-hole pairs, which creates a high potential rise, gets accelerated under the effect of electric field and circulates as the current through an external circuit [4]. The multiplication of square of current with the circuit resistance gives the power which is converted into electricity. The remaining power of the photons raises the cell temperature.

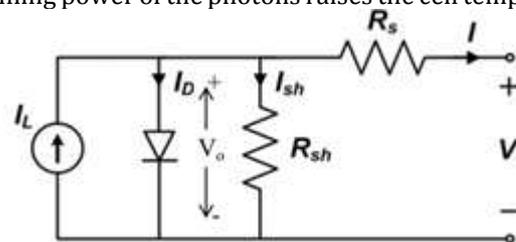


Fig 1. Equivalent circuit of PV module

The equivalent circuit shown in Fig. 1 describes the physics behind PV cell. The circuit behavior determines the output characteristics of Photo voltaic cell. The effect of forward biasing of the p-n junction is represented by the diode. The output current is given by

$$I = I_L - I_D - I_{SH}$$

$$= I_L - I_0 [\exp(qV_0/nKT) - 1] - V_0/R_{sh}$$

Where

V_0 = voltage appearing across diode.

V = load voltage.

I_L = photo generated current.

R_s = internal (series) resistance of the system.

R_{sh} = shunt resistance

I_0 = reverse saturation current of the diode.

T = Temperature in kelvin.

n = Ideality factor (≈ 1.92).

K = Boltzmann constant ($1.38 \times 10^{-23} \text{ J / K}$).

q = electronic charge ($1.6 \times 10^{-19} \text{ C}$)

Maximum Power Point Tracking

The solar energy is converted into usable electrical energy using the PV system, the efficiency is very poor. Maximum power point tracking (MPPT) is a method that is used to extract the maximum power from photovoltaic modules and thus the efficiency of the system is increases. The relationship between solar irradiance, temperature, and resistance produce a variable output. This relationship can be evaluated by the I-V curve. Due to the nature of the I-V characteristic, for a given solar cell temperature and insolation level the output power is maximized at a specific load. The main purpose of the MPPT system is sampling the output of the PV cells for any given environmental condition [1,2]. Proper load resistance is applied to getting maximum power. MPPT devices are usually incorporated into a converter system which provides voltage conversion or current conversion. They also help in regulation operation for various loads

DC to DC converter

DC to DC converter is converting fixed DC to variable DC voltage. It is used to regulate the step up and step down the voltage level. Buck converter decreases the DC voltage level and The Boost converter increases the DC voltage level. It contains of one inductor, one switch as MOSFET and one diode basically. One capacitor should be connected parallel across the load end to maintain the load voltage constant [6]. The switching and duty cycle controls the DC output voltage of the converter.

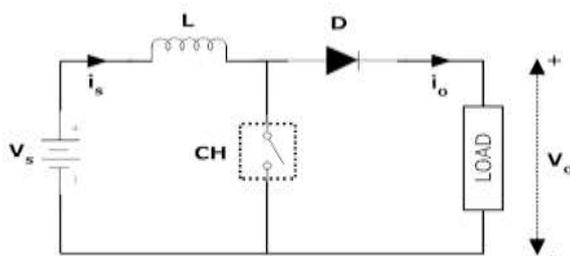


Fig 2 DC to DC converter block diagram

The polarity of the induced emf in inductor is reversed as the current decreases. As a result load voltage V_o exceeds the source voltage V_s . In this manner the step up converter operates and the stored energy in inductor is released to the load.

3. SIMULATION OF PV STANDALONE SYSTEM

Solar Radiation

The maximum solar radiation in Anand is $7.54 \text{ kWh/m}^2/\text{day}$ during the year. Therefore, government and private sector

organizations have been promoting and piloting solar PV systems for rural electrification. The specific monthly solar radiation profile for the selected village is shown in Fig.3 The annual average is $5.78 \text{ kWh/m}^2/\text{day}$. The highest and lowest solar radiation occurs in May and August, respectively. In May, the PV array can satisfy the whole load during the daytime and to meet the load in the evening and night with the energy stored in the battery energy storage systems.

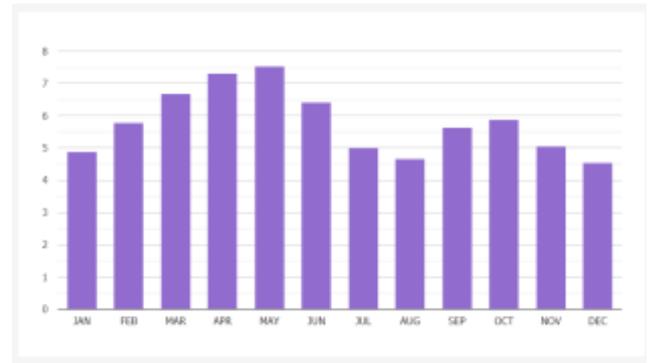


Fig 3 Monthly Solar Radiation Profile of Anand

The city of Anand temperature varies from minimum of 17°C to maximum of 42°C . In order to verify the response of the MPPT controller to temperature variations, the first test case is performed with the system operating at full load while the temperature is varied from 0°C to 45°C .

TABLE I MONTHLY TEMPERATURE AVERAGE IN ANAND

Months	Max.	Min.	Avg.
Jan'18	32	17	26
Feb'18	37	20	30
March'18	39	23	33
April'18	42	27	36
May'18	41	29	36
June'18	35	29	33
July'18	35	28	32
Aug'18	32	26	30
Sep'18	35	26	32
Oct'18	36	25	32
Nov'18	35	21	29
Dec'18	34	19	27

MATLAB Model

The entire stand-alone PV system was designed in MATLAB/Simulink software by using physical electronic components such as resistors, diodes and a current source to represent the equivalent circuit of solar cell by using equation as shown in Fig. 4. Figure illustrates the block

diagram of Boost Converter implemented in MATLAB/Simulink. Since the Boost Converter will be connected to the PV array, the desired mode of converter is achieved. The duty cycle of the switch is controlled by the MPPT controller. The MPPT varies the duty cycle according to the solar irradiation, temperature and load conditions in order to extract maximum power out of the PV array.

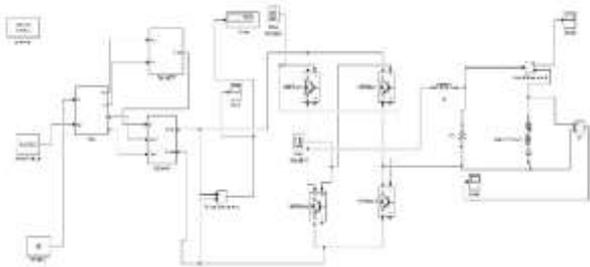


Fig. 4 MATLAB Simulation of PV Module

The simulation model of stand-alone PV system with three loads condition is shown in Fig.5. The three variable loads are 100W, 600W and 1100W respectively.

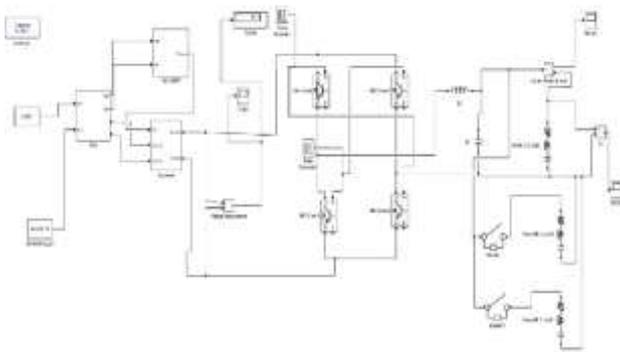


Fig. 5 MATLAB Simulation of PV Module with variable load

The simulation model of stand-alone PV system with three loads condition is shown in Fig.6. In this System we have taken the different Radiation & Temperature according to different seasons of India like winter, summer & monsoon.

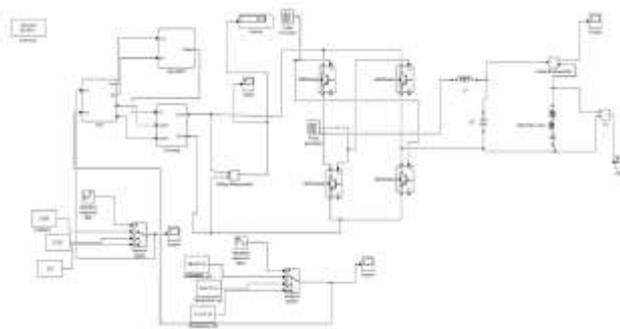


Fig. 6 MATLAB Simulation of PV Module with varying irradiation and temperature

4. RESULTS

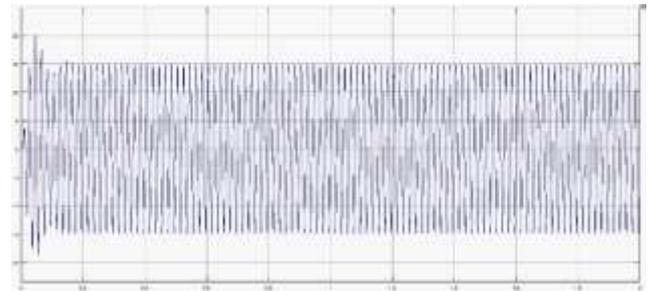


Fig. 7 output current with constant irradiation and temperature

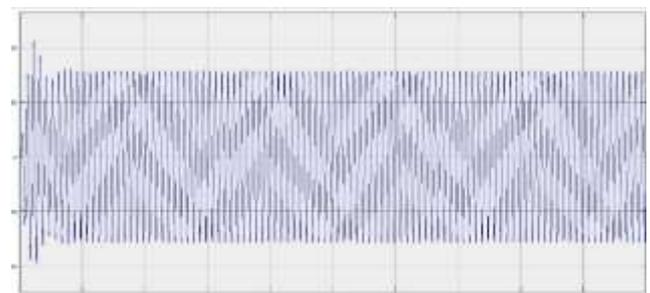


Fig. 8 output voltage with constant irradiation and temperature

Fig 7 and Fig 8 depicts respectively the output voltage and current from the proposed system of PV array at constant solar radiation & constant at 350 w/m² & 40 C° in this simulation respectively.

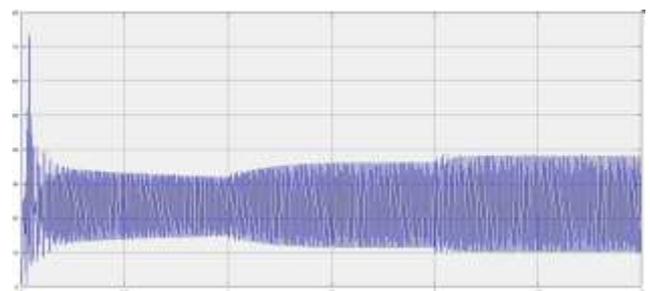


Fig. 9 Converter output voltage with Varying Load

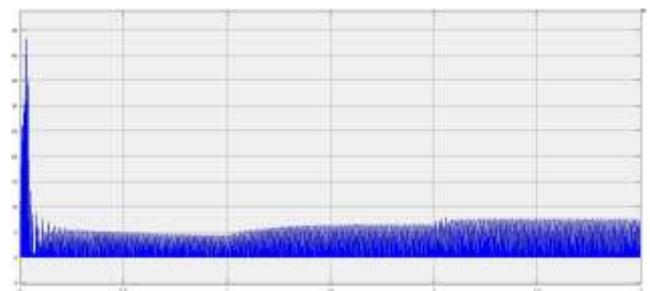


Fig. 10 Converter output Current with Varying Load

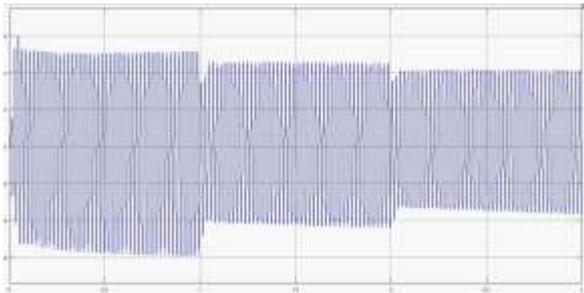


Fig. 11 output voltage with variable load

Fig 11 shows the output voltage from the proposed system of PV array at Variables load in this simulation respectively.

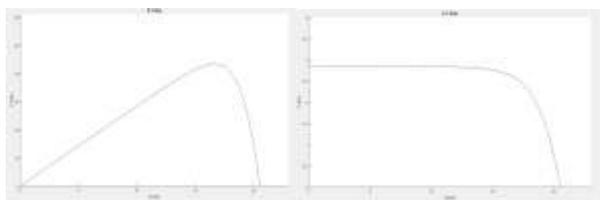


Fig. 12 P-V & I-V Graph at 790 watt/m² irradiation & 38 oC Temperature

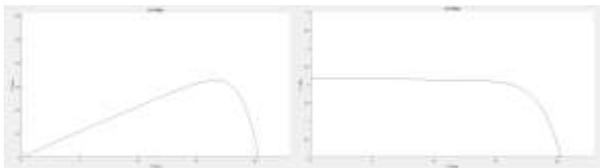


Fig. 13 P-V & I-V Graph at 530 watt/m² irradiation & 28 oC Temperature



Fig. 14 P-V & I-V Graph at 270 watt/m² irradiation & 32 oC Temperature

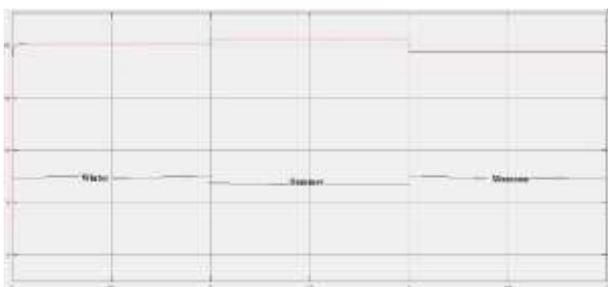


Fig. 15 PV output varying with irradiation and temperature



Fig. 16 Converter output varying with irradiation and temperature

Fig 15 & Fig 16 shows the output voltage and converter output from the proposed system of PV array at different solar irradiation and temperature according to different whether condition.

5. CONCLUSION

Single phase Photo voltaic system has been simulated using MATLAB Simulink. The system has been tested under different load and weather conditions to examine its strength. Different variations in the weather patterns can affect the PV generation. Simulation results further verified that the MPPT controller responds to the different weather patterns accordingly. The simulation results showed that the proposed design exhibited a good performance for the all studied cases and a nice sinusoidal output voltage was obtained.

REFERENCES

- [1] Biks Alebachew Taye, "Design, Modelling and Control of Standalone Photovoltaic System for Rural Electrification in Ethiopia using MATLAB." International Journal of Engineering Trends and Technology (IJETT) - Volume 66 Number 3 - December 2018.
- [2] W.Peng, X. Liu and e. al., "A Hybrid AC/DC Micro-Grid Architecture, Operation and Control," IEEE, 2011.
- [3] N.Zhi, "Power control of dc micro grid with variable generation and energy storage," International Journal of Automation and Power Engineering (IJAPE), vol. 2, no. 4, pp. 252-256, May 2013.
- [4] A.Luque and S. Hegedus, Handbook of photovoltaic science and engineering, West Sussex, England: John Wiley & Sons Ltd, 2003.
- [5] P. H. Zope, Dr. A. J. Patil, Dr. Ajay Somkuwar, "Performance and Simulation Analysis of Single-Phase Grid Connected PV System Based On Z-Source Inverter."
- [6] Usha Sharma, Vikramaditya Dave, "Matlab/Simulink Model Of Two-Stage, Grid Connected 50kw Solar System." 2018 IJRAR July 2018, Volume 5, Issue 3