DESIGNING AND MODELLING OF MPPT TECHNIQUES OF PV CELL USING PID CONTROLLER

Sachin Bhatia,sachin_maya1989@yahoo.com,Shruti Sharma, eee.shruti06@gmail.com,Amit Verma, amit.v.ashu@gmail.com,Department of Electrical Engineering,Faculty of Technology, UTU-campus,Dehradun, India

ABSTRACT

With increasing demand of electrical energy, it plays a very important role in generation. Since energy is the basic infrastructure for the development of a country. There are numerous ways to generate electricity but now a day's many countries are focusing on renewable energy sources instead of non-renewable energy to generate electricity from those sources that are available simply in our surrounding like solar, wind, water etc. Electricity is frequently generated in power stations. Solar was expensive in the past, during the last 30 years but nowadays scientists have come up with a fine and reliable way to extract energy from the sun. As this energy is free of cost and environmental friendly, it found best to extract the energy. Photovoltaic systems convert solar energy easily and directly into electrical energy form.

For the best use of solar energy extraction, in this paper we examine a modeling to extract the maximum power that can be obtainable from a PV system and use this energy for the external use or grid connection. MPPT techniques are being used by many to extract maximum solar power which depends on temperature and solar radiation. In this paper we examine a schematic designing to extract maximum possible energy by using PID controller with PLL. This PID controller technique deals with good measurement of current and voltage and makes MPPT to track with high capabilities and good flexibility under various conditions.

Keywords: mppt; pid controller; online simulation tools.

I. INTRODUCTION

1.1 Types Of Energy

There are different types of energy and energy may be transformed between different forms at various efficiencies.

Renewable energy is the energy that exists freely in the nature. Renewable energy is usually defined as energy that is collected from resources which are naturally replenished on a human being timescale, such as sunlight, wind, rain, waves, and geothermal heat. Renewable energy frequently provides energy in four significant areas: electricity generation, water heating/cooling and air, transportation, and rural (off-grid) energy services. Its types are:

1. Biomass energy: It comes from thing that is once used i.e. wood products, crop residues, aquatic plants and even garbage also. It is also known as 'Natural Material'. Photosynthesis is the process in which plant uses lots of sun's energy to make their food. They store their food in the form of chemical energy. When plants died, the trapped energy is discharged by burning and converted into biomass energy.
2. Wind energy: It is due to the huge convection currents in the atmosphere of earth which is driven by the sun by means of heat energy. It means there will be wind as long as the sun shines.
3. Hydro (water) energy: As the moving water has kinetic energy which can be transferred into useful energy with the help of different ways. Water is stored in dams with the hydroelectric power (HEP) schemes. Water has gravitational potential energy when it falls and it gets released.
4. Geothermal energy: This energy uses of heated water and steam from the earth to run power stations, which in turn produce electricity from the steam. It has a benefit of hot close-to-earth surface radiations to generate electricity or power.
5. Solar energy: Solar power is the energy from the sun. There will be no life without Sun. As this energy is available freely, it is the massive source of energy for many years. We can produce the electricity with the help of the solar energy by means of photovoltaic which converts the solar energy into the useful electric energy. In India, the photovoltaic cells are generally used for irrigation and rural electrification. The procedure of generation electricity is as follows: the photons emit from the sun are immersed in the semiconductor materials and they produce the free electrons. The free electrons have a plenty amount of energy than the electron. Free electrons required field to stream out from the semiconductor to do helpful work.

II. DESIGNING OF PV CELL

A. PV cell

A solar cell or PV cell converts directly light energy into electricity by the effect of photovoltaic which is a physical and chemical phenomenon. It is an electrical device whose electrical characteristics such as current, voltage and resistance vary when exposed to light. Solar cells are building blocks of PV module which is also known as solar panels.

The first PV cells were made up of silicon doped with other elements to change the behavior of electrons or holes i.e. electron absences within atom. Silicon is a popular candidate material for solar PV cells. Other materials like copper indium diselenide (CIS), cadmium telluride (CdTe) and gallium arsenide (GaAs) have been discovered for use in PV cells. Two basic types of semiconductor material are known as positive (or P type) and negative (or N type). Flat pieces of these materials in a PV cell are placed together and the medium between them is known as the P-N junction. The construction is done in such a way that the P-N junction can be exposed to the visible light, IR or UV rays. When these types of radiation strike the junction, a voltage difference is produced between P and N type materials. Electrodes allow current to be drained from the device which is connected to the semiconductor layers.

A photovoltaic system employs solar panels which are composed of numeral solar cells to supply utilizable solar power. The first step involves the photoelectric effect from which electrochemical process takes place which is a second step involving crystallized atoms in a series being ionized, generating an electric current. A photovoltaic cell (PV cell) is a semiconductor diode. Solar PV cell generate power has seen as a clean sustainable energy technology which is the earth's most abundant and widely circulated renewable energy source. This is the direct conversion of sunlight into electricity without any moving parts and there are no environmental emissions during operation.

B. MODELLING OF A PV CELL

A photovoltaic array consists of several photovoltaic cells in series and parallel connections. Series connection made for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the PV array.

In general, a solar cell can be mathematically modeled by a current source and an inverted diode connected in parallel to it. Solar cell has its own series and parallel resistance. Series resistance is due to interference in the path of flow of electrons from n to p junction and parallel resistance for the leakage current.

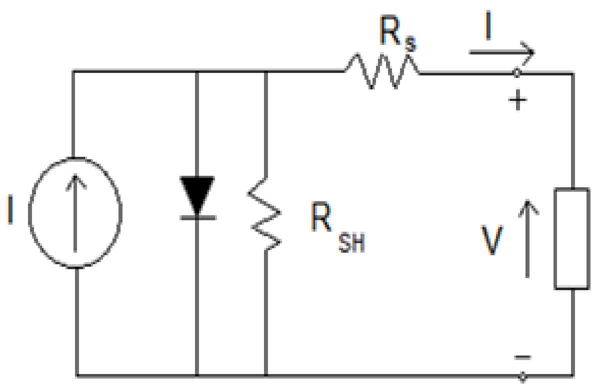


Figure 1. Single diode model of a PV cell

In the above model, we consider a current source (I) along with a diode and series resistance (R_S). The shunt resistance (R_{SH}) is very high connected in parallel having a negligible effect and can be ignored.

The output current from the PV array is:

$$I = I_{sc} - I_d \quad (1.1)$$

$$I_d = I_o[\exp(\frac{qV_d}{kT}) - 1] \quad (1.2)$$

where I_o is the reverse saturation current of the diode, q is the electron charge, V_d is the voltage across the diode, k is Boltzmann constant (1.38 * 10-19 J/K) and T is the junction temperature in Kelvin (K).
From eq. 1.1 and 1.2

$$I = I_{sc} - I_o[\exp\left(\frac{qV_d}{kT}\right) - 1] \quad (1.3)$$

Using suitable approximation

$$I = I_{sc} - I_o\left[\exp\left(q\left(\frac{V + IR_s}{nkT}\right)\right) - 1\right] \quad (1.4)$$

where,
I is the photovoltaic cell current,
V is the PV cell voltage,
T is the temperature (in Kelvin) and
n is the diode ideality factor.

C. MAXIMUM POWER POINT TRACKING

Maximum power point tracking (MPPT), referred to as MPPT, is an electronic system that charge controllers use for wind turbines and photovoltaic solar systems to extract maximum possible power output. It is not a mechanical system that physically moves the solar modules to make them point towards the sun.

Typically, solar panel coverts only 30 to 40 percent of the incoming solar radiation into electrical energy. MPPT technique is used to improve the solar panel efficiency. The voltage at which photovoltaic module can generate maximum power is called maximum power point (or peak power voltage). Maximum power varies with temperature, radiation and solar cell temperature.

According to Maximum Power Transfer theorem, the circuit's output power is maximum when the Thevenin impedance of the circuit or the source impedance matches with the load impedance. Hence our method to track the maximum power point reaches to work for an impedance matching problem.

III. PID CONTROLLER

A PID (Proportional-Integral-Derivative) controller is a widespread instrument used in industrial control systems. A PID controller's job is to uphold the output at a level so that there is no error between the process variable (PV) and the set point (SP). It can be used for regulation of speed, flow, pressure, temperature and other process variables. It is sometimes called a three term controller. PID controllers that are mounted on the field can be placed close to the sensor or to the regulation device and can be monitored centrally using a SCADA system.

In PID, **P** stands for proportional control, **I** for integral control and **D** for derivative control.

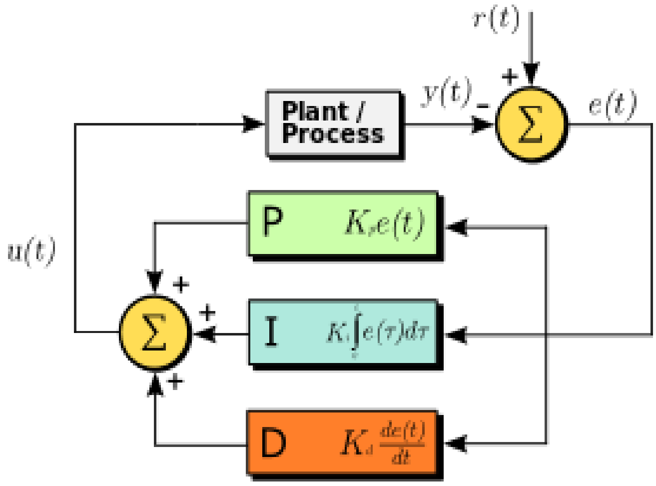


Figure 2. Block diagram of a PID controller in a feedback loop

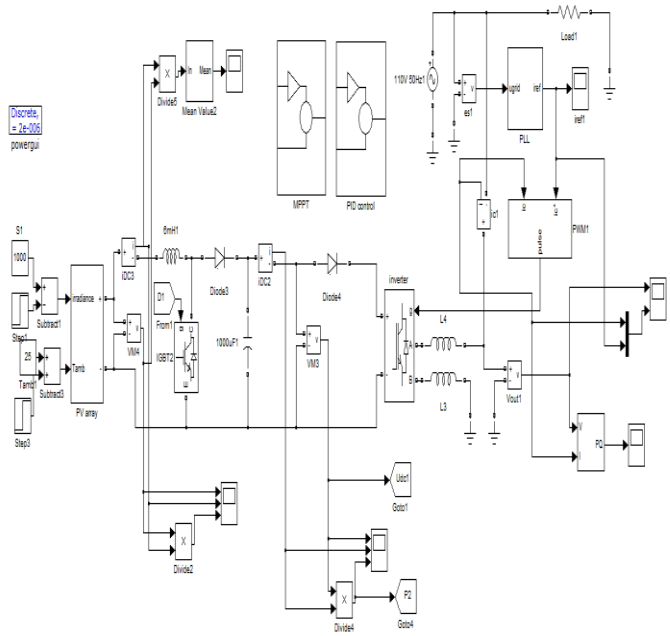
The output of the PID controller is calculated by the summation of proportional, integral, and derivative terms. The output equation of the PID algorithm is:

$$u(t) = K_p e(t) + K_i \int e(\tau)d\tau + K_d \frac{de(t)}{dt}$$

(3.10)

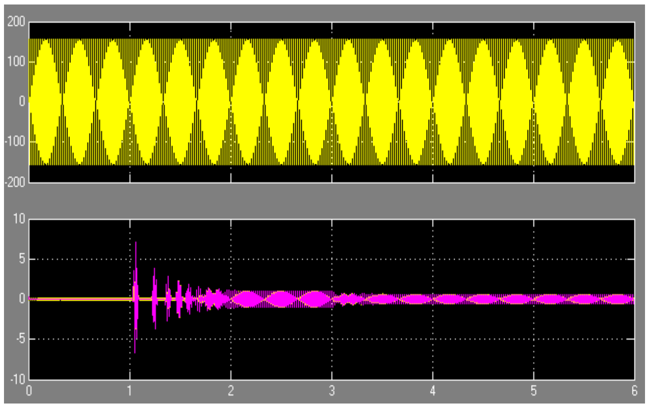
where K_p, K_i, and K_d, denote the coefficients for the proportional gain, integral gain and derivative gain respectively and e is the error defined as: e = SP-PV where SP is set point and PV is process variable.

IV. SIMULATION MODEL

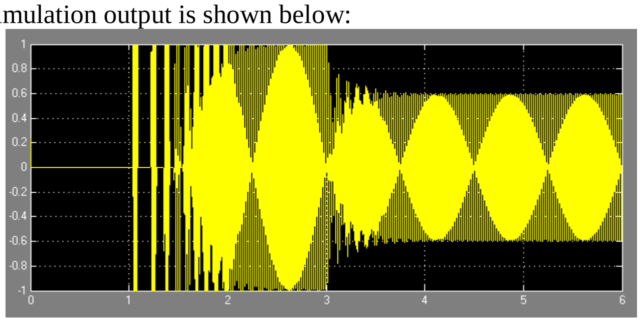


V. RESULT

The output voltage and current waveform is shown. In this scheme we used the feedback system using PID controller and PLL techniques. The output voltage of PV cell inverted in to the 3-Phase AC by using three phase inverter. The output of an inverter fed to the filter side to ripple the dc constant. The simulation output is shown below:



In this figure, the reference current is shown. In the starting the reference current is 0 ampere and after some time the reference current comes into the balance form or ac form. The simulation output is shown below:



VI. CONCLUSION

To extract the maximum power from the solar PV module, many techniques have been developed. A generalized PV module has been developed and tested under various conditions. Different models have been developed with the PV array using MPPT with feedback and without feedback. With feedback system outputs of the voltage and current waveforms shows ripple content and non dc which would produce non-sinusoidal waveform. To improve the performance of the closed loop system we have used a PID controller. PID controller with PLL technique is used which showed a relevant results output. The PV power can be utilized either for remote generation plants or can be utilized for grid integration. In order to produce a pure output (pure sine wave) with low harmonics, L-filter is used. The inverter output voltage can be utilized for grid integration.

REFERENCES

[1] P. Bhatnagar, and R. K. Nema, "Maximum power point tracking control techniques: State-of-the-art in photovoltaic applications," Renewable and Sustainable Energy Reviews, vol. 23, pp. 224-241, 2013.

[2] A. Reza Reisi, M. Hassan Moradi, and S. Jamasb, "Classification and comparison of maximum power point tracking techniques for photovoltaic system: A review," Renewable and Sustainable Energy Reviews, vol. 19, pp. 433-443, 2013.

[3] Mohammed, Elgendy, Bashar Zahawi, and David Atkinson,"Assessment of Perturb and Observe MPPT Algorithm Implementation Techniques," IEEE Transaction on Sustainable Energy, Vol. 3, No.1, Jan 2012.

[4] De Brito, Moacyr Aureliano Gomes, "Evaluation of the main MPPT techniques for photovoltaic applications," *IEEE Transactions on Industrial Electronics*, vol. 60, no.3, pp.1156-1167, 2013.

[5] Z. Liang, R. Guo, J. Li, and A. Q. Huang, "A high-efficiency pv module integrated dc/dc converter for pv energy harvest in freedom systems," Power Electronics, IEEE Transactions on, vol. 26, no. 3, pp. 897–909, 2011.

[6] T. Esram and P. L. Chapman, "Comparison of photovoltaic array maximum power point tracking techniques," Energy conversion, IEEE transactions on, vol. 22, no. 2, pp. 439–449, 2007.