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Improve Performance of Power and Stability Point for Photo Voltaic System by Fuzzy Logic

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Abstract:- A renewable energy had been used in solar power generation since years ago. Solar energy is one of the forms of renewable energy source and it brings benefits to the residential that uses it as their alternative power supply. In order to increases the efficiency of system during rapid changing environmental conditions we propose the fuzzy logic controller. This thesis presents a fuzzy logic methods for variable environmental conditions (i.e. variable temperature and irradiation level), their difficulty while tracking and how those difficulties can be overcome efficiently by the other techniques. We are improving the power results of the PV cells by Fuzzy Logic.

Keywords— *MPP (Maximum Power Point), MPPT (Maximum Power Point Tracking), PSoC (Programmable System on Chip), PV (Photovoltaic) panel.*

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I. INTRODUCTION

Renewable energy is energy generated from natural resources—such as sunlight, wind, rain, tides and geothermal heat—which are renewable (naturally replenished). Renewable energy technologies range from solar power, wind power, hydroelectricity/micro hydro, and biomass and bio fuels for transportation.

Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed.

Alternative energy is a term used for an energy source that is an alternative to using fossil fuels. Generally, it indicates energies that are non-traditional and have low environmental impact. The term alternative is used to contrast with fossil fuels according to some sources. By most definitions alternative energy doesn't harm the environment, a distinction which separates it from renewable energy which may or may not have significant environmental impact.

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a Human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services.

Based on REN21's 2014 report, renewable contributed 19 percent to our energy consumption and 22 percent to our electricity generation in 2012 and 2013, respectively. Both, modern renewable, such as hydro, wind, solar and bio fuels, as well as traditional biomass, contributed in about equal parts to the global energy supply. Worldwide investments in renewable technologies amounted to more than US$ 214 billion in 2013, with countries like China and the United States heavily investing in wind, hydro, solar and bio fuels.

Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency is resulting in significant energy security, climate change mitigation, and economic benefits. In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power.[6] At the national level, at least 30 nations around the world already have renewable energy contributing more than 20 percent of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond.

While many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas and developing countries, where energy is often crucial in human development. United Nations' Secretary-General Ban Ki-moon has said that renewable energy has the ability to lift the poorest nations to new levels of prosperity.

1.2 SOLAR CELL OR PHOTOVOLTAIC CELL

Solar cells, also called photovoltaic (PV) cells by scientists, convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the*PV effect*. The PV effect was discovered in 1954, when scientists at Bell Telephone discovered that silicon (an element found in sand) created an electric charge when exposed to sunlight. Soon solar cells were being used to power space satellites and smaller items like calculators and watches. Today, thousands of people power their homes and businesses with individual solar PV systems. Utility companies are also using PV technology for large power stations. Solar panels used to power homes and businesses are typically made from solar cells combined into modules that hold about 40 cells. A typical home will use about 10 to 20 solar panels to power the home. The panels are mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight. Many solar panels combined together to create one system is called a solar array. For large electric utility or industrial applications, hundreds of solar arrays are interconnected to form a large utility-scale PV system.

Traditional solar cells are made from silicon, are usually flat-plate, and generally are the most efficient. Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or no silicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights.

Third-generation solar cells are being made from a variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics. Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto a very small piece of high efficiency PV material. The PV material is more expensive, but because so little is needed, these systems are becoming cost effective for use by utilities and industry. However, because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the country.

II. PROBLEM STATEMENT

The Perturb and Observe is one of the so called „hill climbing‟ MPPT methods which were developed by F. Iovet al. This method is based on the fact that, on the power voltage (P-V) characteristic curve, at the left of MPP the rate of change of power with respect to voltage is greater than zero i.e. dP/dV> 0 while at the right, variation becomes less than zero i.e. dP/dV< 0. Fig.1 shows the power voltage (P-V) characteristic curve of Perturb and Observe (P&O) algorithm. As shown in figure, when the operating voltage of the PV panel is perturbed in a given direction and dP/dV> 0; it is known that the perturbation moved the panel‟s operating point toward the MPP. The P&O algorithm would then continue to perturb the PV panel voltage in the same direction. If dP/dV< 0 then the change in operating point moved the PV panel away from the MPP and the P&O algorithm reverses the direction of the perturbation.

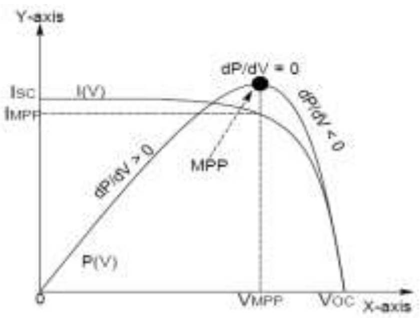

Fig.1. Sign of *dP/dV*at different position on the power-voltage characteristic of a PV cell.

A similar hill climbing MPPT algorithm is the Incremental Conductance (INC). This method intends to improve the P&O by replacing the derivative of the power versus voltage *dP/dV*used by the P&O with the PV panel instantaneous conductance *(I/V)* and incremental *(dI/dV)* conductance, according to (1) and (2).

$$\frac{dP}{dV_{pv}} = \frac{d(V_{pv}I_{pv})}{dV_{pv}} = I_{pv} + V_{pv}\frac{dI_{pv}}{dV_{pv}} \tag{1}$$

$$\left(\frac{1}{V_{pv}}\right)\frac{dP}{dV_{pv}} = \frac{I_{pv}}{V_{pv}} + \frac{dI_{pv}}{dV_{pv}} = G + dG \tag{2}$$

Where *G* is the conductance of PV cell and *dG*is the incremental conductance PV cell. The main objective of this method is to find the distance of PV operating point from the Maximum Power Point and can determine when the MPP has been reached and hence stop the perturbation. At maximum power point, the variation of power with operating point voltage of PV cell becomes zero .

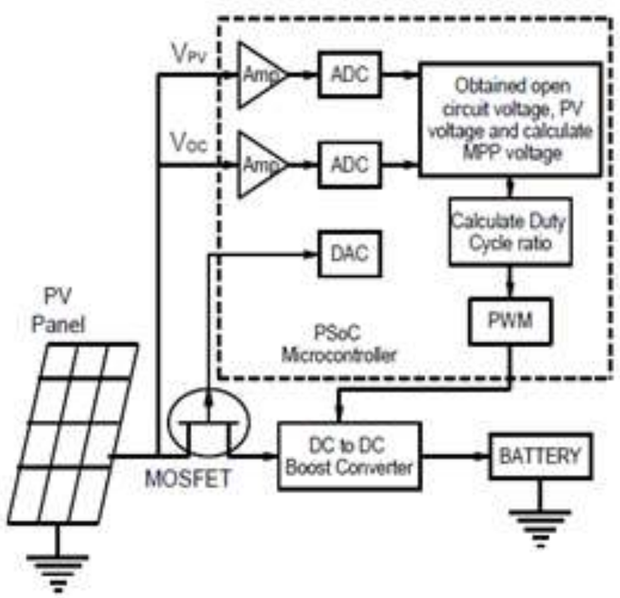

Fig.3.Block diagram of PV System.

Photovoltaic (PV) is the field of technology related to the application of solar cells for energy by converting sunlight directly into electricity. Fig.3 shows the development of PV system as it composed of different parts like PV panel, charge storage device in the form of battery, DC to DC boost converter and controlling part. The smallest part of a PV panel is called photovoltaic cell. The electric energy from the solar cells is stored in the battery for immediate or later use. A Programmable System on Chip (PSoC) is used as an intelligent controller whose major role is to regulate the voltage and current from the solar cells before it is stored in the battery. It monitors the condition of the battery state of charge and protects the battery from being over charged. The charge controller also protect the battery from discharging below its lowest acceptable voltage.

III. DESIGN DESCRIPTION

Renewable sources of energy acquire growing importance due to massive consumption and exhaustion of fossil fuel. Among several renewable energy sources,Photovoltaic arrays are used in many applications such as water pumping, battery charging, hybrid vehicles, and grid connected PV systems. As known from a (Power-Voltage) curve of a solar panel, there is an optimum operating point such that the PV delivers the maximum possible power to the load. The optimum operating point changes with the solar irradiation, and cell temperature. Therefore, on line tracking of the maximum power point of a PV array is an essential part of any successful PV system. A variety of maximum power points tracking (MPPT) methods are developed. The methods vary in implementation complexity, sensed parameters, required number of sensors, convergence speed, and cost [1]. The Used algorithm is divided into two major parts: maximum power computation, and direct power control of the power drawn from the PV.The maximum power is computed online using a modified perturb and observe algorithm. The computed maximum power is compared with instantaneous actual PV power, the error between reference (maximum) power and actual power activates ON/OFF controller with a hysteresis band to drive the buck chopper. Therefore, the instantaneous power extracted from the PV is maintained between the tolerance bands.

A solar cell basically is a p-n semiconductor junction. When exposed to light, a dc current is generated. The generated current varies linearly with the solar irradiance. The standard equivalent circuit of the PV cell the basic equation that describes the (I-V) characteristics of the PV model is given by the following equation.

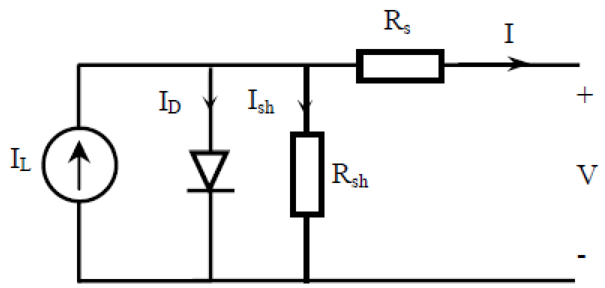

Figure 3.1:- Equivalent circuit of PV solar cell

$$I = I_L - I_o\left(e^{\frac{q(V + IR_s)}{kT}} - 1\right) - \frac{V + IR_s}{R_{sh}}$$

Where: I is the cell current (A). IL is the light generated current (A). Io is the diode saturation current. q is the charge of electron = 1.6x10-19 (coul). K is the Boltzmann constant (j/K). T is the cell temperature (K). Rs, Rsh are cell series and shunt resistance (ohms). V is the cell output voltage (V).

The problem considered by MPPT methods is to automatically find the voltage VMPP or current IMPP at which irradiance. In this section, commonly used MPPT methods are introduced in an arbitrary order.

The method is based on the observation that, the ratio between array voltages at maximum power VMPP to its open circuit voltage VOC is nearly constant.

$$V_{MPP} \approx k_1 V_{OC}$$

This factor *k1* has been reported to be between 0.71 and 0.78. Once the constant *k1* is known, VMPP is computed by measuring VOC periodically. Although the implementation of this method is simple and cheap, its tracking efficiency is relatively low due to the utilization of inaccurate values of the constant *k1* in the computation of VMMP.

The method results from the fact that, the current at maximum power point IMPP is approximately linearly related to the short circuit current ISC of the PV array.

$$I_{MPP} \approx k_2 I_{SC}$$

Like in the fractional voltage method, *k2*is not constant. It is found to be between 0.78 and 0.92. The accuracy of the method and tracking efficiency depends on the accuracy of K2 and periodic measurement of short circuit current.

In P&O method, the MPPT algorithm is based on the calculation of the PV output power and the power change by sampling both the PV current and voltage. The tracker operates by periodically incrementing or decrementing the solar array voltage. If a given perturbation leads to an increase (decrease) in the output power of the PV, then the subsequent perturbation is generated in the same (opposite) direction. So, the duty cycle of the dc chopper is changed and the process is repeated until the maximum power point has been reached. Actually, the system oscillates about the MPP. Reducing the perturbation step size can minimize the oscillation. However, small step size slows down the MPPT. To solve this problem, a variable perturbation size that gets smaller towards the MPP. However, the P&O method can fail under rapidly changing atmospheric conditions. Several research activities have been carried out to improve the traditional Hill-climbing and P&O methods. Reference [4] proposes a three-point weight comparison P&O method that compares the actual power point to the two preceding points before a decision is made about the perturbation sign. Reference [5] proposes a two stage algorithm that offers faster tracking in the first stage and finer tracking in the second stage.

The method is based on the principle that the slope of the PV array power curve is zero at the maximum power point.

(dP/dV) = 0. Since (P = VI), it yields:
$\Delta I/\Delta V = - I/V$, at MPP (4.a)
$\Delta I/\Delta V > - I/V$, left of MPP

$\Delta I/\Delta V < - I/V$, right of MPP

The MPP can be tracked by comparing the instantaneous conductance (I/V) to the incremental conductance ($\Delta I/\Delta V$). The algorithm increments or decrement the array reference voltage until the condition of equation (4.a) is satisfied. Once the Maximum power is reached, the operation of the PV array is maintained at this point. This method requires high sampling rates and fast calculations of the power slope.

IV. PROPOSED METHODOLOGY

Power from solar panel is affected by isolation and temperature variation which can be minimized by FUZZY logic system. To extract maximum power from solar system, perturb and observe technique of Fuzzy logic is used. A PV system require proper battery charge controller to balance the power flow from PV system to battery and load such that photovoltaic power is utilized effectively. In this buck boost regulator is used to controls the charging process of battery. MATLAB/Simulink model is used to analyze the converter, modal evaluation and parameter extraction.

In the design PV system, we use three types of controller for compare the results.

1:- Without any Controller

2:- PID controller

3:- Fuzzy Logic controller

So we compare the results in between these three conditions and will show that from fuzzy we are getting maximum power. We use switches for change the controller. As shown in image.

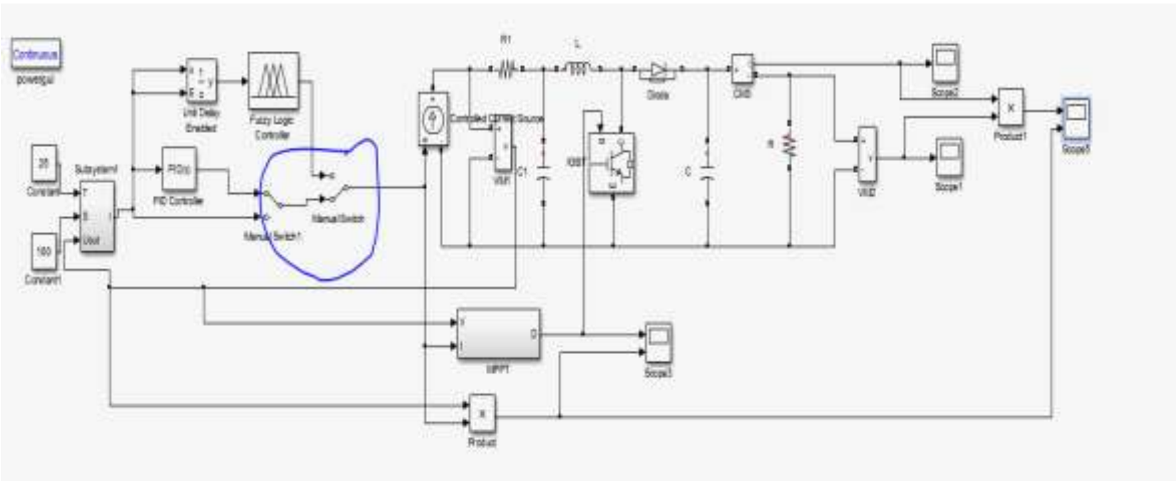

Fig 4.1:- Design systemwith fuzzy logic and PID controller

V. RESULTS

When no controller is applied then the value of the stability is going high. That means system is getting stable after a long time. As the image is showing the stability is taking two overlaps.

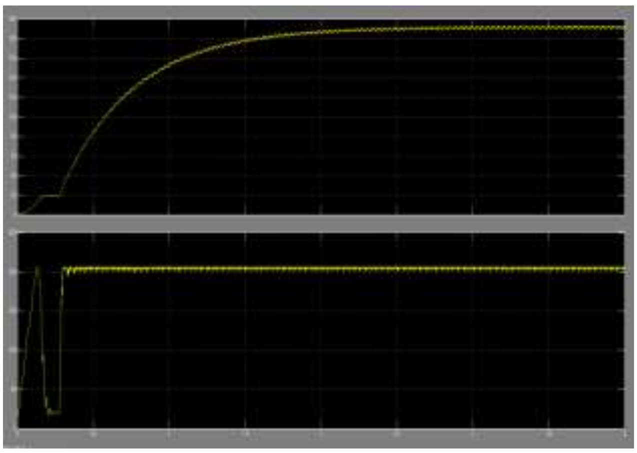

Fig 5.1:- Output Waveform without controller

When we apply the PID controller then the output value get some stability.

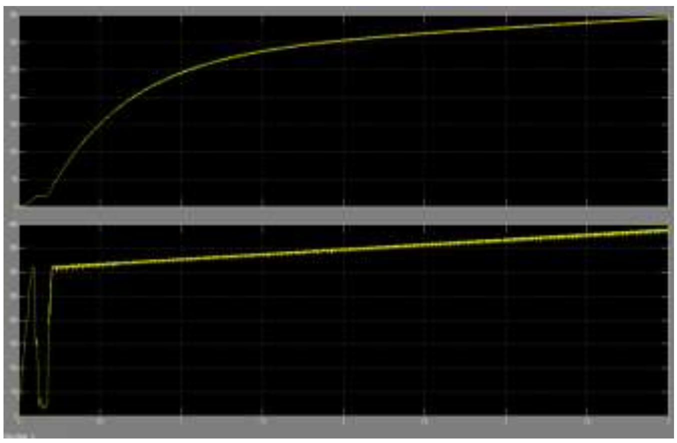

Fig 5.2:- Output waveform with PID controller

When we apply the fuzzy logic the system stability gives only one overlap that means system is getting more stable as compare to PID .

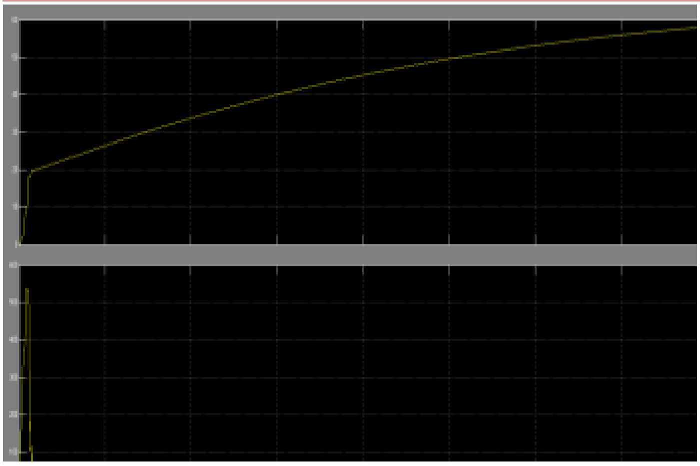

Fig 5.3:- Output Waveform with Fuzzy logic controller

VI. CONCLUSION

Solar power source is abundant. Many types of PV cells are in development to meet to PV Roadmap for future needs PV cells' efficiency can be increased and underdevelopment solar power from PV cell are safe and potentially growing.

This thesis presents an overview of the fuzzy logic methods and their difficulty of tracking, in the fast changing environmental conditions. Solar energy is one of the forms of renewable energy source and it brings benefits to the residential that uses it as their alternative power supply. In order to increases the efficiency of system during rapid changing environmental conditions system will adapt some fuzzy logic methods. This paper presents a review on various fuzzy methods for variable environmental conditions (i.e. variable temperature and irradiation level).Apart from all the methods, an open circuit and slope detection tracking technique is found to be an efficient technique with respect to tracking speed and accuracy. This technique can avoid the unnecessary amount of power loss and therefore maintaining the power efficiency.