EXPERIMENTAL ANALYSIS OF PERTURB AND OBSERVER AND INCREMENTAL CONDUCTANCE MPPT BASED SOLAR TRACKING SYSTEM

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ABSTRACT

This paper presents a detailed analysis of the two most well-known hill-climbing maximum power point tracking (MPPT) algorithms: the perturb-and-observe (P&O) and incremental conductance (INC). The purpose of the analysis is to clarify some common misconceptions in the literature regarding these two trackers, therefore helping the selection process of MPPT

Keywords—Perturb and Observer, Incremental Conductance, Microcontroller, DC Servo motor. Maximum Power Point Tracking (MPPT)

I. INTRODUCTION

A photovoltaic system is a system which uses one or more solar panels to convert solar energy into electricity. The solar cell is the basic unit of a PV system. An individual solar cell produces direct current and power typically between 1 and 2 W, hardly enough to power most applications. It consists of multiple components, including the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and or modifying the electrical output. PV cells are made of semiconductor materials, such as silicon [2]. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other.When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current - that is, electricity. This electricity can then be used to power a load. A PV cell can either be circular or square in construction.

II. MATERIAL AND METHODOLOGY

Various materials have been investigated for solar cells. There are two main criteria -efficiency and cost. Efficiency is a ratio of the electric power output to the light power input. Ideally, near the equator at noon on a clear day; the solar radiation is approximately 1000 W/m². So a 10% efficient module of 1 square meter can power a 100 W light bulb. Costs and efficiencies of the materials vary greatly. By far the most common material for solar cells (and all other semiconductor devices) is crystalline silicon. In this system used Poly or crystalline Solar Panel

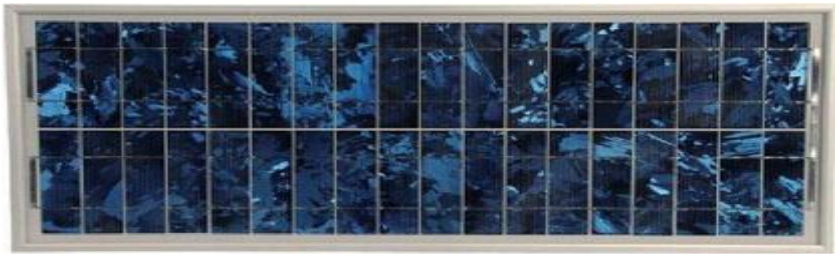

Fig 1. Poly or crystalline Solar Panel

It is made from cast ingots - large crucibles of molten silicon carefully cooled and solidified. These cells are cheaper than single crystal cells, but also somewhat less efficient. However, they can easily be formed into square shapes that cover a greater fraction of a panel than Monocrystalline cells, and this compensates for their lower efficiencies

A solar tracker is a device that orient photovoltaic array toward the sun. In flat-panel PV applications trackers are used to minimize the angle of incidence between the incoming light and a photovoltaic panel. Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a mechanical tracking system that "physically moves" the modules to make them point more directly at the sun [11] MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. Additional power harvested from the modules is then made available as increased battery charge current. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different. MPPT is a technique that grid connected inverter, solar battery charges and similar devices use to get the maximum possible power from one or more photovoltaic devices, typically solar panel through optical power transmission .solar cell has complex relation between solar irradiation, temperature and total resistance that produces a non-linear output efficiency which can be analyzes based on the current-voltage curve. It is the purpose of the MPPT system to sample the output of the cell and apply the proper resistance (load) to obtain maximum power for any given environment condition. MPPT devices are typically integrated into an electric power converter that provides voltage or current conversion, filtering and regulation for driving various loads, including power grid, batteries or motor.

This increases the amount of energy produced by the photovoltaic array. Perturb and Observe method, the controller adjust the voltage by a small amount from the array and measure power. This method can result in oscillation of power output. It is referred as hill clamping method because it depends on curve of power against the voltage below the maximum power point and the full above that point. This method is easy to implementation and this method may result in top level efficiency, provided that a proper predictive and adaptive till clamping strategy is adopted. In this method a slight perturbation is introduce system. This perturbation causes the power of the solar module changes. If the power increases due to the perturbation then the perturbation is continued in that direction. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. When the steady state is reached the method oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. The method is developed in such a manner that it sets a reference voltage of the module corresponding to the peak

voltage of the module. A PI controller then acts moving the operating point of the module to that particular voltage level. It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions. But still this method is very popular and simple. Incremental Conductance method, Incremental conductance method is the algorithm that exhibits better performance than other techniques. It is more efficient, accurate, rapid and low cost technique without need for complicated mathematical operations and is independent of device physics. This control scheme can easily implemented using low cost microcontrollers and writing the program needs just a little literacy in C language and familiarity with programming. The time complexity of perturb & observe algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing on both the directions. When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm. However the method does not take account of the rapid change of irradiation level (due to which MPPT changes) and considers it as a change in MPP due to perturbation and ends up calculating the wrong MPP. To avoid this problem we can use incremental conductance method. The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method. In this I used dual axis tracking system

Fig 2 Dual Axis Tracking system

III. DESIGN OF PERTURB AND OBSERVER AND INCREMENTAL CONDUCTANCE

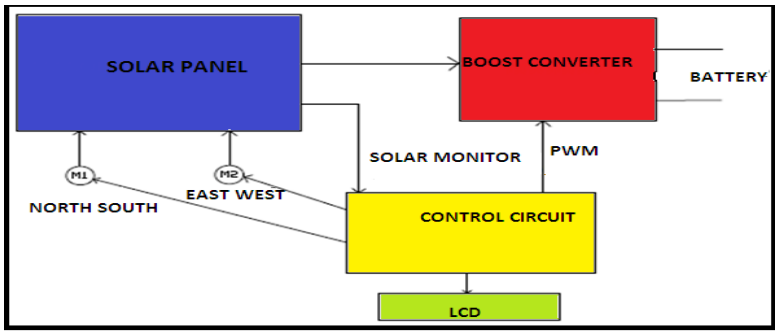

Fig 3 System Block Diagram

In this project I have used a 37 watt peak power solar module with a short circuit current of 2.24 Amps. With an open circuit voltage of 21.89 volts, a boost converter is needed to charge the 24-volt battery. As shown in Figure 3.1. In order to ensure that solar panel operates at its maximum power point, we measure and monitor both the current and voltage of the solar panel. This will be accomplished by a high side current monitor and simple resistor divider on the solar panel's output voltage. In order to control the output power of the solar panel, we manipulate the panel's output current vide a software algorithm for which way to manipulate the current, e.g. whether the current out of the solar panel should be increased or decreased. To make the Maximum Power Point Converter work, the functions of the boost converter need to be merged with the solar panel's output load. The boost converter is either storing current in the boost inductor (switch closed) or it is delivering current from the boost inductor to the load (switch opened). When the boost inductor is storing current, the current comes from the solar panel. In essence, the boost inductor is the solar panel's load. By making the current stored in the boost inductor programmable, the load of the solar panel becomes programmable. This is the principal on how the maximum power point converter works. The maximum power point converter combines a boost converter, a programmable current oscillator and a software algorithm to maximize the power out of a solar panel.[1]

IV. MECHNICAL SYSTEM

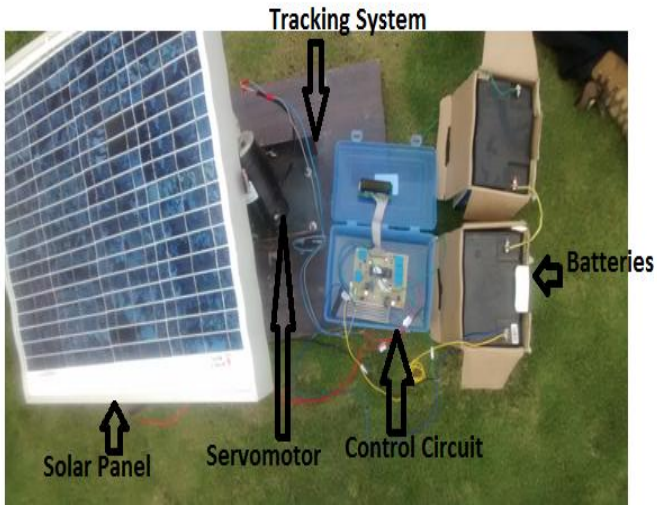

Fig 4. Actual solar tracker design

After the solar panels and other components were selected, the overall structural design of the solar tracker was fabricated. The entire structure was fabricated using the mild steel plates as shown in fig. 2 The pillar holding panel is aligned to the centre of the panel for better flexibility during the panel rotation [4]. The tracker is designed to have a multi-axis rotation (East-west and North-South), and the motor is mounted in such a way that the tracker systems have a multi-axis freedom of rotation. The solar tracker consists of the PV cells, the charge

controller and the battery. Other subsystems such as the PIC microcontroller-16F877A were also used. The electrical energy is then stored in the lead-acid battery that is later used to power the respective component [8]

V. EXPERIMENT RESULT

It was necessary to compare the experiment results for the perturb and observer and incremental conductance of solar tracker system. To obtain this data, simple experiments were performed. The setups were installed on ground The readings are as shown in Table 1 and 2

1 Perturb and Observer Method

Time	Irradiance(W/m$^{2)}$	Solar Voltage (V)	Solar Current (I)	Solar Power (W)
9.00 am	325.82	11.36	0.23	2.61
9.15 am	328.23	11.75	0.32	3.76
10.00 am	468.39	15.25	0.79	12.04
11.15 am	596.33	16.32	1.16	18.93
12.30 pm	1414	18.97	1.72	32.62
12.45 pm	1411	19.32	1.76	34
1.00 pm	1412	19.75	1.78	35.15
1.15 pm	1410	20.12	1.8	36.21
1.45 pm	1400	19.22	1.75	33.63
2.00 pm	1380	18.92	1.72	32.54
3.30 pm	1180	14.82	1.16	17.19
5.00 pm	545	11.92	0.4	4.76

Table 1: Solar output of PV panel in tracking mode (P&O)

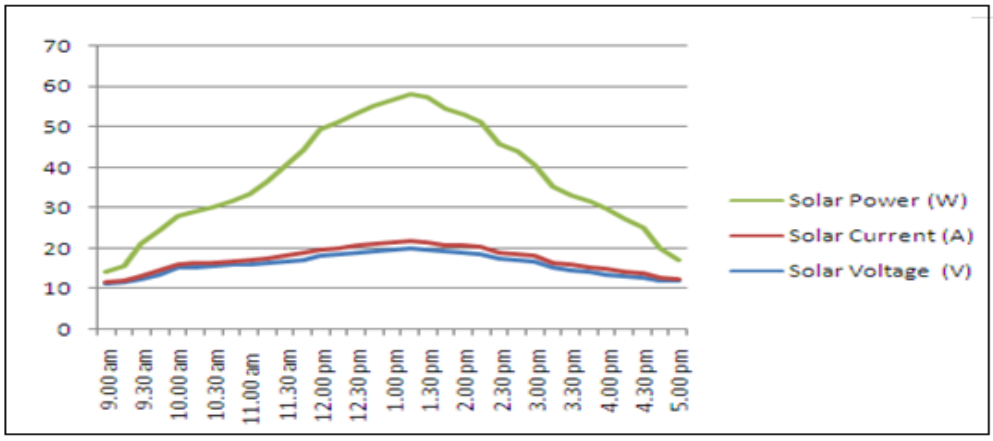

Fig 5. Wave Form Of Perturb & Observer

2 Incremental Conductance Method

Time	Irradiance (W/m^2)	Solar Voltage (V)	Solar Current (A)	Solar Power (W)
9.00 am	422	11.38	0.24	2.73
9.15 am	328.23	11.75	0.33	3.87
10.00 am	468.39	15.3	0.79	12.08
11.15 am	596.33	16.42	1.17	19.21
12.30 pm	1414	18.99	1.72	32.66
12.45 pm	1411	19.42	1.76	34.17
1.00 pm	1412	19.75	1.78	35.15
1.15 pm	1410	20.13	1.8	36.23
1.45 pm	1400	19.28	1.75	33.74
2.00 pm	1380	18.96	1.72	32.61
3.30 pm	1180	14.82	1.16	17.19
5.00 pm	545	11.82	0.4	4.72

Table 2: Solar output of PV panel in tracking mode (IC)

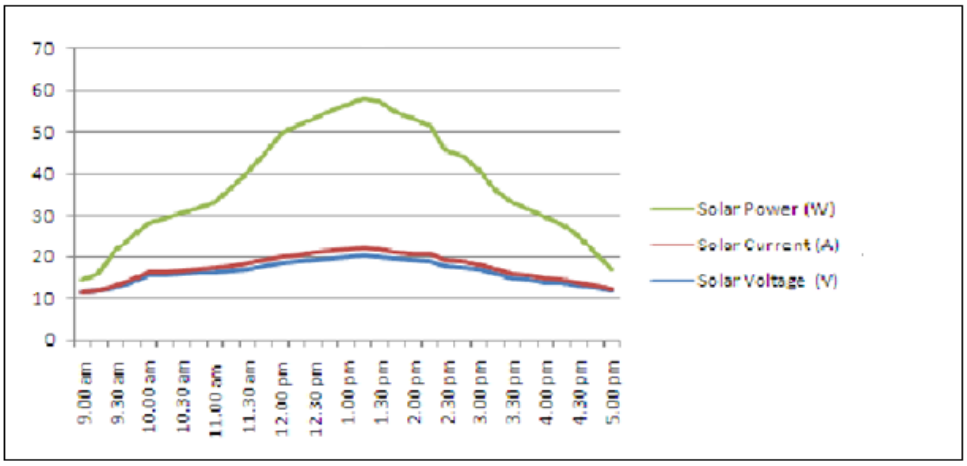

Fig 6. Wave Form Of Incremental Conductance

VI. CONCLUSION

After examining the information obtained in the data table section and in plotted graph, It has been shown that the incremental conductance method can collect maximum energy than perturb and observer method and high efficiency is achieved through this mppt tracking system.

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