Design and Construction of Automatic Solar Tracking System

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***Abstract* -** Solar Energy is radiant energy and heat coming from the sun is used in a range of evolving technologies such as solar heating and solar thermal energy. Solar energy has become an alternative approach for the limited fossil fuel resources. One of the simplest and most direct applications of solar energy is the conversion of solar radiation into heat that can be used in water heating system. It will increase countries energy security through inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower. For converting sun radiant energy into heat energy, it is required to use a flat plate collector for exchanging the heat using the greenhouse effect. Solar energy is one of the most reliable alternative energy source in this modern era. Thousand researches on improving the efficiency of photovoltaic (PV) system are ongoing to make it more competitive among all other available renewable energy sources. Photovoltaic panels are used to collect solar energy and convert it into electrical energy.

Several studies were carried out by scholars in order to improve the Construction of Automatic Solar Tracking System in recent years. The concrete objective of this paper is to design Construction of Automatic Solar Tracking System in order to improve the efficiency of the Solar Tracking System. In this paper I have analyzed the Automatic Solar Tracking System. In order to verify the proposed method, an experiment was designed and constructed. we can easily overcome this problem by using sun tracking solar panel system. Solar tracking system is one of the best approach to harvest more solar energy from PV system compared to fixed panel system. Solar tracker follows the position of the sun throughout the day from east to west in a daily and seasonal basis. This paper presents the performance comparison between fixed panel, single-axis and sun tracking solar panel system. On the basis of solar irradiance, output power and total energy have been calculated for three different solar panel system throughout a year including every single month. Moreover, this paper contains graphical comparison of output power and total energy for three different systems and also for different months including various seasons.

I. INTRODUCTION

Solar Energy is touted to be the 3rd most renewable power source with the help of photo voltaic technology. Industrially advanced countries e.g. Germany, Italy, China and the USA are ranked to be the top countries with highest installed capacity of solar PV power. According to the studies of International Energy Agency in 2010, ostensibly, global solar PV capacity could reach 3000 GW or in other words, 11% of total projected global energy production by the year 2050. Therefore, it can be safely presumed that to combat the acute shortage of power as well as to meet with the ever increasing demand of energy solar energy, in near future, will emerge as a fitting and applicable substitute to other power sources. But what exactly is Solar power. Solar energy is becoming an alternative for the limited fossil fuel resources. Solar Energy is radiant light and heat from the sun that is used in a range of evolving technologies such as solar heating and solar thermal energy. The traditional PV is more or less 15% efficient which indicates a larger chunk of the sunlight that hits the panel don't get converted into electricity. However, after the invention of photovoltaic modules in the 1950s, a lot of research and studies have gone into rendering the process more effective and beneficial. This technology has evolved a lot since the beginning of its use and scientists have come up with a number of solutions so as to modernize and revolutionize the fundamental underlying ideas of PV systems. One of it is known as concentrated photovoltaic system or CPV. Contrary to conventional PV, this one uses lenses and curved mirrors so as to concentrate sunlight and force that onto highly efficient multiple junction panels. CPV often comprises tracker system and cooling system to increase the efficiency further. Experiments showed that the efficiency of CPV can reach as much as 33% under standard test conditions and by mid 2020s, the efficiency rate is expected to hit as high as 50%. 3rd generation photovoltaic cells: 3rd generation PV systems, although much not in use, could potentially overcome the limitation in power efficiency for single band gap solar cells.

One of the main methods of increasing efficiency is to maximize the duration of exposure to the Sun. Tracking systems help achieve this by keeping PV solar panels aligned at the appropriate angle with the sun rays at any time. The goal of this project is to build a prototype of light tracking system at smaller scale, but the design can be applied for any solar energy system in practice. It is also expected from this project a quantitative measurement of how well tracking system performs compared to system with fixed mounting method.

A Solar Tracker is a device onto which solar panels are built-in which tracks the motion of the sun ensuring that maximum amount of sunlight strikes the panels all over the day. Power output from a solar cell will be maximum when it is facing the sun i.e. the angle between its surface and sun rays is 90 degree. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun. The components used for its construction are DC motor, Microcontroller and LDR. The active sensors continuously monitor the sunlight and alternate the panel towards the direction where the intensity of sunlight is maximum. In this project, it's divided by two categories; hardware and software. In hardware part, 2 light dependent resistor (LDR) has been used to trace the synchronize of sunlight by detecting brightness level of sunlight. For rotation part, one standard servo motor has been selected. In software part, the code is constructed in C programming and inserted in Arduino. This project is designed for low power and portable application. Therefore, it's suitable for rural area usage. Moreover, the effectiveness of output power which collected by sunlight are increased.

II. EXPERIMENTAL INVESTIGATION

Specifications of Proposed Work

- Panel Size : 150 x 150 mm (6V)
- No of Battery : 3 (12V)
- No. of LDR : 2
- Voltage Regulator : 7805
- Microcontroller : 89S52
- No of Resistance : 5
- DC Gear Motor : 3.5 rpm (12V)
- Motor Driver IC : L293D
- Transister : 548
- Gear : 2

Description

The solar tracker designed here has one degree of rotation. The solar tracker can track the sun only in horizontal direction (that is, from east to west). The algorithm is based on the difference of solar irradiance at different position. Voltage detected by the solar panel at different position will be compared and the optimum position will be found. The motion of this tracker panel is controlled by a variable reluctance DC motor. The tracker sensor is a 5 Watts solar panel. For large scale power plant project, an individual tracker, placed on a high tower can be used to detect the position of sun and then the data can be used to rotate a set of solar panels to that specific direction according to signal.

The experiment was conducted from 08.00 am to 5.00 pm on different days . The instantaneous efficiency of the Panel was estimated. Based on the observed data graphs were drawn.

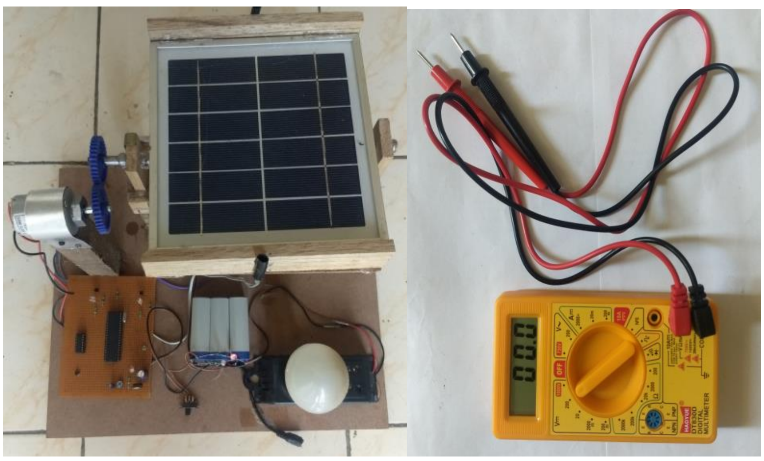

Fig. 1 The Experimental arrangement of Solar Tracking System

The design has three main units-

- Position Sensor Unit
- Motor Unit
- Controller Unit

The sensor unit performs the detection of difference of solar irradiance due to chance in position of sun. The control unit decides on the motion of tracker analyzing the input detected by sensors and sends necessary signals to track the sun. The motor unit performs the tracking operation physically. Hence the control unit is a connection between the other two units.

III. RESULT AND DISCUSSION

The performance assessment of Solar panel at different positions are discussed below- Stationary Position: The power generated by Solar Panel at Stationary position that is 23.5°with the horizontal & other two axis are fixed is maximum at 12:00 noon & drop with respect to the time. The maximum power generated by Solar panel is 6.70 V at 1:30PM.

Tracking Position: The power generated by Solar Panel at Tracking position that is 23.5°with the horizontal & other two axis are fixed is maximum at 12:00 noon & drop with respect to the time. The maximum power generated by Solar panel is 13.2W at 13:00PM.

The input stage is designed with a voltage divider circuit so that it gives desired range of illumination for bright illumination conditions or when there is dim lighting. This made it possible to get readings when there was cloudy weather. The LDRs were found to be most suitable for this project because their resistance varies with light. They are readily available and are cost effective. Temperature sensors for instance would be costly. The control stage has a microcontroller that receives voltages from the LDRs and determines the action to be performed. The microcontroller is programmed to ensure it sends a signal to the servo motor that moves in accordance with the generated error. DC motors are noise free and are affordable, making them the best choice for the project.

EXPERIMENTAL INVESTIGATION FOR SOLAR PANEL

Max^{m} Temp: - 42℃ Min^{m} Temp: - 28 ℃ Date:-21/05/2019

Sl. No.	Time	Multi meter Reading of Rechargeable Battery in Voltage (V)	Multi meter Reading of Solar Panel in Voltage (V)
1	8:00	11.60	6.41
2	9:00	11.62	6.36
3	10:00	11.63	6.32
4	11:00	11.64	6.35
5	12:00	11.65	6.38
6	13:00	11.68	6.50

7	14:00	11.70	6.32
8	15:00	11.71	5.90
9	16:00	11.71	5.45
10	17:00	11.72	4.72

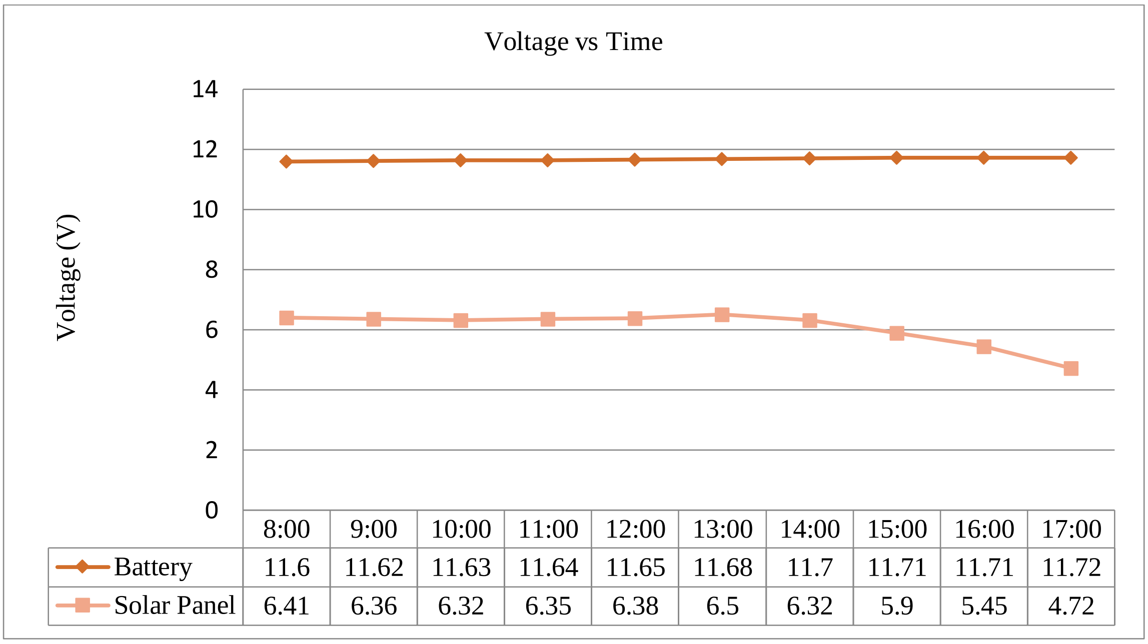

Fig. 5.1 Variation of Maximum Voltage (V) w.r.to Time

EXPERIMENTAL INVESTIGATION FOR SOLAR PANEL

<u>TABLE-5.2 OBSERVATION TABLE 2</u>

Max^{m} Temp: - 40℃ Min^{m} Temp: - 27℃ Date:-22/05/2019

Sl. No.	Time	Multi meter Reading of Rechargeable Battery in Voltage (V)	Multi meter Reading of Solar Panel in Voltage (V)
1	8:00	11.60	6.42
2	9:00	11.72	6.47
3	10:00	11.75	6.52
4	11:00	11.76	6.55
5	12:00	11.77	6.59
6	13:00	11.80	6.60
7	14:00	11.81	6.61
8	15:00	11.83	6.50
9	16:00	11.83	6.46
10	17:00	11.84	6.43

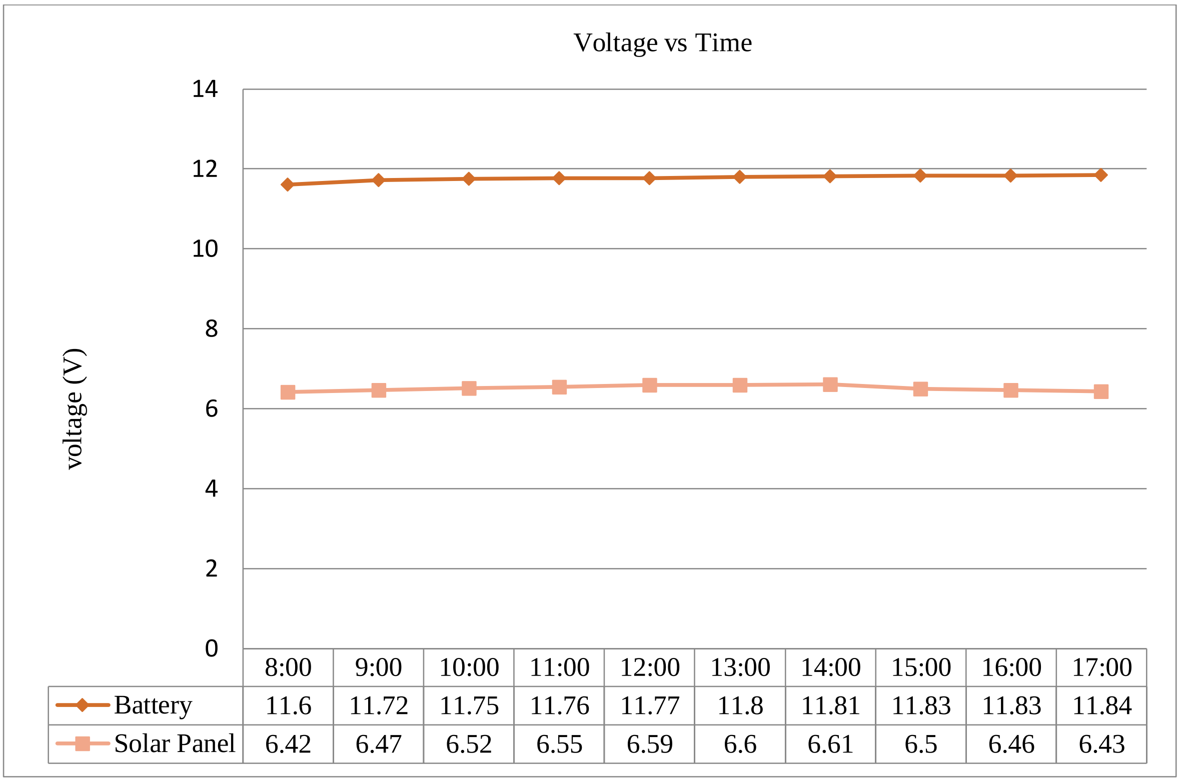

Fig. 5.2 Variation of Maximum Solar panel Voltage (V) w.r. toTime

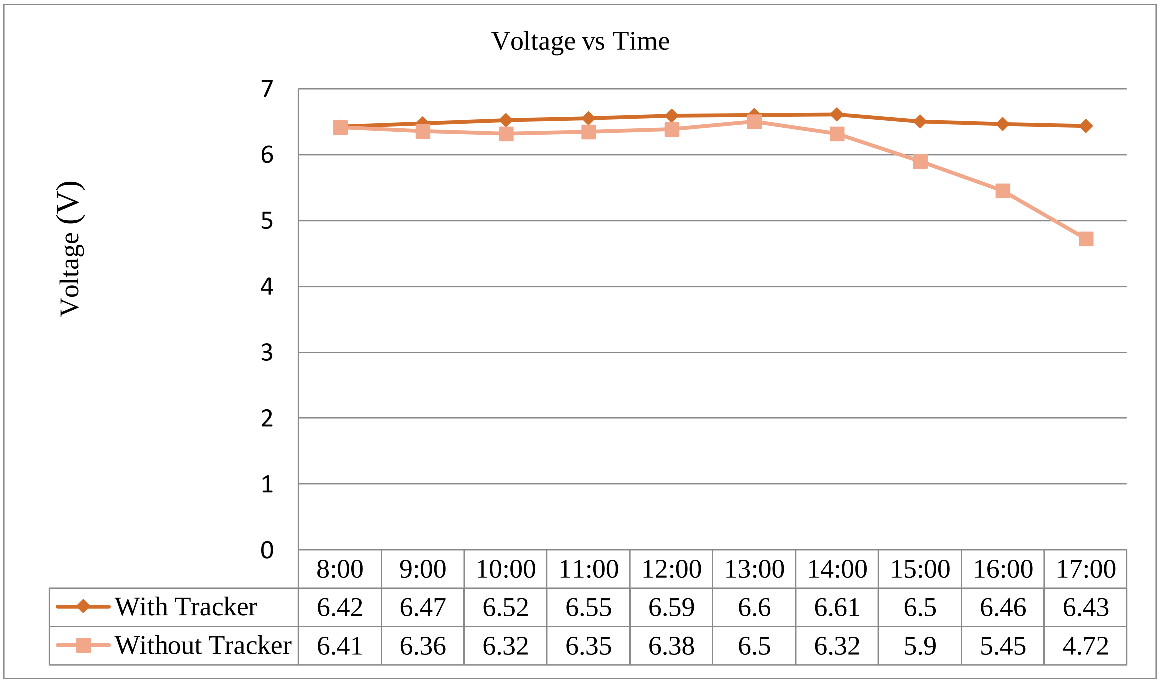

Fig. 5.3 Comparison and Variation of Solar panel voltage (V) w.r.to Time

IV. CONCLUSIONS AND FUTURE SCOPE

Conclusion

Solar energy is an unlimited source of energy. Solar tracker is used to harness this energy with more efficiency. This paper has demonstrated the implementation of solar tracking system in a cost effective way. Direct use of output data from solar panel makes the system independent of light sensor that requires external biasing circuit. The use of DC motor ensures more accurate tracking with minimum error. Thus, the proposed design offers a better solution to the implementation of solar energy.

In order to solve the power crisis and meet the future increasing need, solar power must be extracted as much as is possible. Maximum cultivation of solar power can be performed by using solar tracker modules. The tracker designed here is much reliable and less power consuming then traditional trackers. Hence, it can be a better solution to maximum solar power extraction.

The energy gain, using solar tracking systems, will depend mainly on the system used and the location, since this is the main variable for determining the available irradiation. Latitude alone is not sufficient as a unique variable for the determining the irradiance levels. The solar radiation has no linear behavior as a function of the latitude as some authors have stated. On cloudy days which have only a diffuse radiation component, the tracking systems are not increasing the amount of energy collected.

Future Scope

With the available time and resources, the objective of the project was met. The project is able to be implemented on a much larger scale. For future projects, one may consider the use of more efficient sensors, but which are cost effective and consume little power. This would further enhance efficiency while reducing costs. If there is the possibility of further reducing the cost of this project, it would help a great deal. This is because whether or not such projects are embraced is dependent on how cheap they can be. Shading has adverse effects on the operation of solar panels. Shading of a single cell will have an effect on the entire panel because the cells are usually connected in series. With shading therefore, the tracking system will not be able to improve efficiency as is required.

There is a huge variety of studies concerning solar tracking systems. However, there are still enough research fields available. On the one hand, the simulations could be validated in more places, using the right methods and power plants. The radiation sensors should also be replaced installing the adequate instruments like pyranometers instead of the photovoltaic detectors. This would help with the reflectance problem of the PV-cells and probably with the influence of high temperature, among other disadvantages that are present at the PV-detectors. With solid simulation models and plenty of working solar power plants, some other factors could be analyzed in detail and quantified.

The reflection on the solar modules, the module temperature dependence of the power performance and the wind incidence could be studied. In the future the study of solar tracking systems could be extended to other methods used to capture the sun’s radiation like multi-junction PV cells, solar thermal systems and photovoltaic concentrators. More than studying the tracking systems itself, like it was done at this work, an efficiency comparison could be made between different technologies under optimized conditions, to determine the most efficient solar power systems. An example could be a PV tracker with multi-junction PV cells compared to a photo-voltaic collector systems.

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