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Design and Construction of a Single Axis Solar Tracker

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Abstract

The detection of the position of the sun and analysis of this control system was carried out on a single axis solar tracking system. The tracker consists of a photovoltaic panel and moves its surface approximately to the right angle to the sun to obtain maximum possible photon energy and convert it to electrical energy. One way to increase efficiency is by implementing a solar tracking system for solar panel in such a way that the rays from the sun fall perpendicularly on the solar panel and thus ensure it capture of maximum available solar energy. The tracker periodically followed the path of the sun throughout the daytime. This research employed the method of active tracking system where the position of the sun is continuously determined by the sensors during the day. The sensor triggers the motion of motor. Active tracking is accurate with the help of sensors. The maximum output PV voltage is 5.6v.

Keywords: Photovoltaic (PV), Active solar tracker, and Efficiency.

INTRODUCTION

Photovoltaic (PV) technology is the technology of converting the solar energy into electrical energy. The efficiency of this energy conversion is not satisfactory. It depends on solar radiation, ambient temperature, wind speed, optimal matching of the system with the load and appropriate spatial placement of the module at optimal inclination angle to the horizontal plane. Solar trackers are the devices that track the solar path throughout the daytime and orient photovoltaic panels, reflectors, lenses or other optical devices toward the sun. Since the sun's position in the sky changes with time (about 15 degrees per hour) and the altitude angle and azimuth angle varies continuously, trackers are used to align the collection system to maximize energy production. Several types of single-axis tracker and dual-axis trackers have been developed in the last decade after the development of light sensitive sensors. For medium to large scale production PVs with solar tracking facility saves much more energy that would have been wasted if tracking not performed. The daily average output of the PV system can be enhanced by a solar tracker, which forces sunlight to be incident perpendicularly on to the PV cells throughout the day (Patel M.R, 2006).

The benefit of using tracking devices is derived from the fact that the incidence angle of the direct component of solar radiation is more favorable than angular incidence that corresponds to fixed systems. Since the characteristics of the diffuse component for both systems is approximately the same, the instantaneous solar radiation collected by the photovoltaic modules, assembled in a tracking system, is higher than the critical irradiance level for a longer number of hours than in fixed systems. Numerous experiments have been performed upon the benefit of solar tracking system revealing that up to 40% of additional energy can be attained by adopting solar tracking method (Clifford M. J, 2004).

The use of solar tracker not only uses to increase the availability of daily solar energy but also increases the solar irradiance at a given time by permitting it to reach an irradiance threshold under which the system cannot run. The solar trackers previously designed used light dependent resistors (where voltage across it changes as irradiance change the conductance of the substance)/ photo conductors, photo diode (current through it depends on irradiance) and photo transistors (here the collector current/drain current depends on irradiance) as sensors (Ritchie E, 2009).These devices are not independent to operate. They require biasing for operation, which is an energy consuming method. Besides, in order to track in single axis they require more than two sensors. If one of the sensors' characteristic is different from the other, or changes due to weather condition or time or other unexpected effects, or one sensor gets under cloud, then the tracker will fail to track the position of sun. On the other hand, this new design uses only one sensor, which is actually a solar panel of smaller size and power (5 Watt). This sensor is independent of biasing voltage. The panel itself can generate voltage according to solar irradiance. The change of property of the sensor does not affect the sensing algorithm, thus easily avoids false triggering problem. Also, the surface area of the sensor is significant. Hence, there is less probability of false triggering due to shadows of the cloud. It is also found that the solar tracker designed here causes less error in the detection of the position of the sun (Argeseanu A, 2009).

The main objective of this research is to improve the efficiency in the design specifically on single axis solar tracker and also to compare the calculated values with experimental and available results on single axis solar tracker.

LITERATURE REVIEW

Khlaichom, P *et al*. (2007) observed the high-concentration solar requires the sun to be tracked with great precision for maximum output voltage. This paper trend in solar concentrator tracking system is to use an open-loop local controller that computes the direction of the solar vector based on geographical location and time. But it is not sufficient accuracy because it has error from computing the sun's position, mechanical, controller systems and installation. The genetic algorithms (GA) are one technique for solving these problems. In this research, Genetic algorithm increases the accuracy of solar tracking system by using wolf's theory that receives maximum solar radiation, so the system becomes on-line. The system will manage machine to positions of each answer population from an initial set of accidental solutions and estimate by measure voltage from sensor, then produce the next generation by using intersect operator, mutation operator and selection. In the experimental, statistical method has a great for finding the best parameters of GA. The experiment result shows that the performance increases about 7.084% by using genetic algorithm.

However, Lorenzo, E *et al*. (2002) presented that solar tracking is used in large grid-connected photovoltaic plants to increase solar radiation collection for reducing the cost of delivered electricity. Single vertical axis tracking, also called azimuth tracking has a capacity for energy gains up to 40%, as compare with optimally tilted fully static arrays. This paper examined the theoretical aspects associated with the design process of azimuth tracking, by taking into account of shadowing between different trackers and back-tracking features. Single, horizontal, North–South-oriented axis tracking system is associated with flat-plate modules represent by far the most extended tracking solution in current PV plants. Because of their intrinsic lack of shadowing in the North–South direction, single tracking devices can be drive large surfaces and due to the horizontal axis position, wind loads tend to be relatively low It involves a particularly simple and strong mechanical construction, which is a great advantage of this type of tracking.

Helwa, N H *et al*. (2007) has provided that the output energy from any solar energy system depends on the solar energy input to that system. Solar energy input depends on the type of tracker, because every tracking system has distinct capacity of gaining the solar radiation. A practical study was carried out on different solar tracking systems. The layout of these systems consist of a fixed system facing south and tilted 400 a vertical-axis tracker, a 60 tilted-axis tracker, and a two-axis tracker. All the trackers depend on the microprocessor based controlled systems, and every system has photovoltaic arrays for electric energy generation. The performance of the different systems is based on a complete year input of solar radiation and the electric power output from them. The study also consists of the effect of some operating parameters on the tracking operation. This study showed that the collected solar energy as well as the electrical output energy of the tracking solar systems is more than that of the stationary system. Chicco, G et al. (2008) presented the performance of grid connected photovoltaic (PV) systems with parallel-connected converters. This paper concentrates the two paths for energy production. The first part concerns the evaluation of the energy production in Sun-tracking configurations, comparing their performance according to fixed PV systems. The second part is related to the harmonic characteristics of a number of converters in PV plants of various sizes. The PV plants of different types (in fixed or Sun-tracking configurations) are increasing diffusion and sizes (from a few kW to several MW) with inverter connection to the grid are requiring detailed analyses concerning their aggregation and the assessment of their performance. The Sun-tracking configurations are capable to provide significant increase in the energy production over fixed systems of equivalent characteristics, provided that the availability of the moving parts can be guaranteed and that mutual shading conditions are avoided. The harmonic and inter harmonic summation ratios have been used to represent the effect of harmonics and inter harmonics of different orders to the assessment of the total current of the PV aggregation. The use of a semi empirical approach for harmonic summation seems more suitable than other statistical techniques in order to create a reference model for evaluating the total current.

METHODOLOGY

The single axis solar tracker is the apparatus in which the sun powered board tracks the sun from east to west utilizing a solitary turn point to pivot. Under this framework there are three sorts: Horizontal single pivot following framework, Vertical single hub following framework and Tilted single hub following framework. In the Horizontal framework the hub of turn is flat concerning the ground, and the substance of the module is arranged corresponding to the pivot of revolution. In the Vertical framework the hub of turn is vertical regarding the ground and the essence of the module is arranged at a point as for the hub of pivot while In the Tilted following framework the pivot is among flat and vertical and this additionally has the essence of the module situated corresponding to the hub of revolution, like the Horizontal following framework. The single hub following framework comprises of two LDR's set on either side of the board. Contingent upon the force of the sunbeams one of the two LDR's will be shadowed and the other will be enlightened. The LDR with the most extreme force of the sun's radiation imparts more grounded sign to the controller which thus imparts sign to the engine to turn the board toward the path in which the sun's power is greatest.

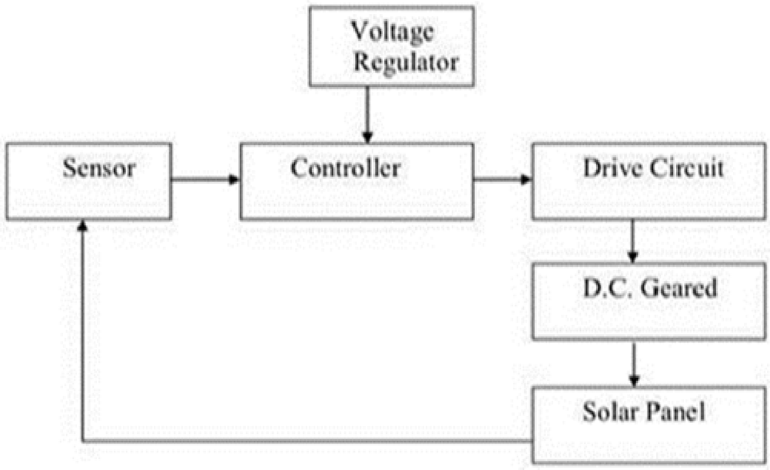

Figure 1: Single axis solar tracker

Results

Table 1: Photovoltaic output voltage result.

Time	Output
06:00	1.3V
07:00	2.6V
08:00	4.3V
09:00	4.9V
10:00	5.1V
11:00	5.3V
12:00	5.4V
13:00	5.5V
14:00	5.6V
15:00	5.3V
16:00	4.9V
17:00	4.2V
18:00	3.7V

Table 2: Light Sensor Circuit Test Results.

Time	LDR1 Output	LDR2 Output
06:00	0.277 V	0.276 V
07:00	0.504 V	0.509 V
08:00	1.757 V	1.933 V
09:00	1.631 V	1.783 V
10:00	1.900 V	1.798 V
11:00	2.910 V	2.969 V
12:00	1.990 V	1.990 V
13:00	1.985 V	1.990 V
14:00	0.976 V	0.985 V
15:00	0.941 V	0.892 V
16:00	0.824 V	0.594 V
17:00	0.128 V	0.981 V
18:00	0.982 V	0.968 V

DISCUSSIONS

From the tables, it can be seen that the maximum sunlight occurs at around midday, with maximum values obtained between 1200 hours to 1400 hours. In the morning and late evening, intensity of sunlight diminishes and the values obtained are less that those obtained during the day .For the panel fitted with the tracking system, the values of the LDRs are expected to be close. This is because whenever they are in different positions there is an error generated that enables its movement. The motion of the panel is stopped when the values are the same, meaning the LDRs receive the same intensity of sunlight. For the fixed panel, the values vary because the panel is at a fixed position. Therefore, at most times the LDRs are not facing the sun at the same inclination. This is apart from midday when they are both almost perpendicular to the sun. Days with the least cloud cover are the ones that have the lightest intensity and therefore the outputs of the LDRs will be highest. For cloudy days, the values obtained for the tracking system and the fixed system do not differ too much because the intensity of light is more or less constant. Any differences are minimal. The tracking system is most efficient when it is sunny. It will be able to harness most of the solar power which will be converted into energy. In terms of the power output of the solar panels for tracking and fixed systems, it is evident that the tracking system will have increased power output. This is because the power generated by solar panels is dependent on the intensity of light. The more the light intensity the more the power that will be generated by the solar panel. The objective of the project was to design a system that tracks the sun for a solar panel. This was achieved through using light sensors that are able to detect the amount of sunlight that reaches the solar panel. The values obtained by the LDRs are compared and if there is a significant difference, there is actuation of the panel using a servo motor to the point where it is almost perpendicular to the rays of the sun.

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