International Journal of Applied Research in Mechanical Engineering

Volume 1 | Issue 2 Article 10

October 2011

Fabrication and Experimental Study on Two-Axis Solar Tracking

Hemant Kumar Nayak
Hindustan College of Science and Technology, Mathura-281122, Uttar Pradesh, India, hemant.kumar008@rediffmail.com

Fabrication and Experimental Study on Two-Axis Solar Tracking

Hemant Kumar Nayak[1*], Manoj Kumar[2], Nagendra Prasad[3], Rashmi Rekha Behera[4]
[1,2,3]Mechanical Engineering department
[4]Electrical& Electronics Engineering Department
Hindustan College of Science and Technology, Mathura-281122, Uttar Pradesh, India
**Corresponding author (E-mail:-hemant.kumar008@rediffmail.com)*

Abstract : This paper presents the design and experimental study of a two axis (azimuth and Polar) automatic control solar tracking system to track solar PV panel according to the direction of beam propagation of solar radiation. The designed tracking system consists of sensor and Microcontroller with built in ADC operated control circuits to drive motor. Two steeper motors are used to move the system panel, keeping the sun's beam at the center of the sensor. The measured variables are compared with the fixed axis. The results indicate that the energy surplus becomes about (45-56%) with atmospheric influences. In case of seasonal changes of the sun's position there is no need to change in the hardware and software of the system. . Considering all above aspects of this tracking system it can be concluded that, it is a flexible tracking system with low cost electromechanical set-up, low maintenance requirements and ease on installation and operation.

Introduction

Energy is the keyword for mankind since everything is revolved around the Energy, be it human being or animals or plants, every one needs Energy in one form or the other. Energy is needed not only for the survival of the mankind but also for further healthy all round growth. Higher the consumption of Energy, higher would be the growth of the country as socio-economic development of nation depends on Energy availability and Energy consumption. In short energy is one of the essential indicators of the prosperity of society.

Solar Energy

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic's (PV), or indirectly using concentrated solar power (CSP). CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect. Concentrating Solar Power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. A wide range of concentrating technologies exists; the most developed are the parabolic trough, the concentrating linear Fresnel reflector, the Sterling dish and the solar power tower. Various techniques are used to track the Sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage. A parabolic trough consists of a linear parabolic reflector that concentrates light onto a receiver positioned along the reflector's focal line. The receiver is a tube positioned right above the middle of the parabolic mirror and is filled with a working fluid. The reflector is made to follow the Sun during the daylight hours by tracking along a single axis. Parabolic trough systems provide the best land-use factor of any solar technology. The SEGS plants in California and Acciona's Nevada Solar Onenear Boulder City, Nevada are representatives of this technology. The Suntrof-Mulk parabolic trough, developed by Melvin Prueitt, uses a technique inspired by Archimedes' principle to rotate the mirrors.

Need for tracking

The sun's position in the sky varies both with the seasons and time of the day as the sun moves across the sky. Solar powered equipment works best when pointed at or near the sun, so a solar tracker can increase the effectiveness of such equipment over any fixed position, at the cost of additional system complexity.

Solar Tracker

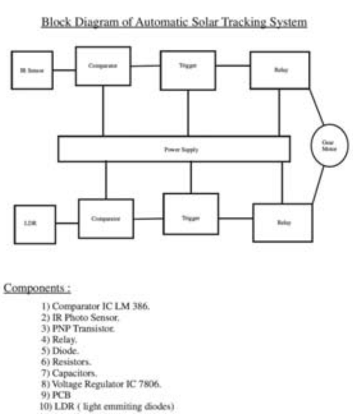
A solar tracker is a generic term used to describe devices that orient various payloads toward the sun. Payloads can be photovoltaic panel's reflectors, lenses or other optical devices. In standard photovoltaic (PV) applications trackers are used to minimize the angle of incidence between the incoming light and a photovoltaic panel. This increases the amount of energy produced from a fixed amount of installed power generating capacity. In standard photovoltaic applications, it is estimated that trackers are used in at least 85% of commercial installations greater than 1MW from 2009 to 2012.

Photovoltaic

The photovoltaic effect is the creation of a voltage (or a corresponding electric current) in a material upon exposure to light. Though the photovoltaic effect is directly related to the photoelectric effect the two processes are different and should be distinguished. In the photoelectric effect, electrons are ejected from a material's surface upon exposure to radiation of sufficient energy. The photovoltaic effect is different in that the generated electrons are transferred between different bands (i.e. from the valence to conduction bands) within the material, resulting in the buildup of a voltage between two electrodes. In concentrated photovoltaic (CPV) and concentrated solar thermal applications trackers are used to enable the optical components in the CPV and CSP systems. The optics in concentrated solar applications accepts the direct component of sun light and therefore must be oriented appropriately to collect energy. Tracking systems are found in all concentrator applications because systems do not produce energy unless oriented toward the sun.

Tracker types: Tilted single axis tracker (TSAT)

All trackers with axes of rotation between horizontal and vertical are considered Tilted Single Axis Trackers. Tracker tilt angles are often limited to reduce the wind profile and decrease the elevated end height off the ground. With backtracking, they can be packed without shading perpendicular to their axis of rotation at any density. However, the packing parallel to their axis of rotation is limited by the tilt angle and the latitude. Tilted Single Axis Trackers typically have the face of the module oriented parallel to the axis of rotation. As a module tracks, it sweeps a cylinder that is rotationally symmetric around the axis of rotation.



Dual axis trackers

Dual axis trackers have two degrees of freedom that act as axes of rotation. These axes are typically normal to one another. The axis that is fixed with respect to the ground can be considered a primary axis. The axis that is referenced to the primary axis can be considered a secondary axis. The orientation of the module with respect to the tracker axis is important when modeling performance. Dual Axis Trackers typically have modules oriented parallel to the secondary axis of rotation.

Tip – tilt dual axis tracker (TTDAT)

A Tip – Tilt Dual Axis Tracker has its primary axis horizontal to the ground. The secondary axis is then typically normal to the primary axis. The posts at either end of the primary axis of rotation of a Tip – Tilt Dual Axis Tracker can be shared between trackers to lower installation costs. The axes of rotation of Tip – Tilt Dual Axis Trackers are typically aligned either along a true north meridian or an east west line of latitude. It is possible to align them in any cardinal direction with advanced tracking algorithms. Manufacturers include Patriot Solar Group. Point focus parabolic dish with Sterling system. The horizontally rotating azimuth table mounts the vertical frames on each side which hold the elevation for the dish and its integral engine/generator mount

Toggle switch

It is a class of electrical switches that are manually actuated by a mechanical lever handle or rocking mechanism. Toggle are available in many different styles and sizes and are used in contactless applications .many are designed to provided the simultaneous actuation of multiple sets of electrical contacts. The word “toggle” is a reference to a kind of mechanism or joint consisting of two arms, which are almost in line with each other, connected with an elbow-like pivot. However, the phrase “toggle switch” is applied to a switch with a short handle and a positive snap-action, whether it actually contains a toggle mechanism or not.

Automatic solar tracking system

Introduction

The efficiency of solar panel is greatly affected by various factors such as angle of attack of sun rays, angle of incident, light intensity and duration of light. To increase the efficiency for maximum output it is important to face the solar panel perpendicular to the sun rays for longer time, it is not possible for the fixed solar panel mountings to achieve maximum output we have design the mechanism which rotates the solar panel perpendicular to the sun rays throughout the day. And reset automatically for next cycle or next stage. for this purpose various designs are used by different researchers & institutes but making an energy efficient low power consumption, less wear –tear designed is not possible. Here we present simple but efficient design of solar tracking (one-axis) is presented by using radiation tunneling & detection method. This system is consists of photo sensors, LDR (light dependent resistor), comparators, trip switches, gear motors, batteries, solar panels & some discrete components. It turns lights on at night (dark) & off during day (light) automatically. This device is based on light dependent resistors (LDR), when light falls on LDR the resistance of LDR keeps low % at dark resistance of LDR goes high enough & to stop the flow of current & circuit build around transistor trigger the relay to operate any electrical gadget.

Working principle

This circuit is based on light dependent resistors (LDR), when light falls on LDR the resistance of LDR keep decreasing the current passing through the LDR increases, vice-versa ,when in dark the resistance of LDR increases & current passing through LDR decreases & base current for forward biasing of transistor T1 is decreases ,so that no output at the collector of T1 obtained. At night (dark) resistance of LDR increases which decreases the negative feedback for forward biasing of transistor & transistor T1 get sufficient positive voltage to trigger the transistor & get output at the collector of transistor to drive relay (electromagnetic switch) which operate any desired electrical gadgets or lights..The other circuit having the second IC LM386 works exactly in the same way except that the photo sensor here has been replaced by the LDR and two relays (Relays 2&3) have been used which change polarity of the motors so that it can run and move the panel in both clockwise and anti-clockwise direction.

Experimental result analysis:

Testing without tracking:-

HOUR	VOLTAGE	CURRENT	POWER
8	4.5	7.5	2.7
9	6.2	7.45	5.15973
10	7.3	7.4	7.201351
11	8.5	6.9	10.47101
12	9	6.7	12.08955
13	8.5	6.6	10.94697
14	8.1	6.5	10.09385
15	7.3	7.1	7.505634
16	6.9	7.4	6.433784
17	6	7	5.142857

Testing with tracking

HOUR	VOLTAGE	CURRENT	POWER
8	6.9	1.352941	9.335294
9	7.8	1.529412	11.92941
10	8.3	1.66	13.778
11	8.5	1.7	14.45
12	9.5	1.938776	18.41837
13	8.8	1.79598	15.80408
14	8.1	1.6875	13.66875
15	7.8	1.659574	12.94468
16	7.5	1.470588	11.02941
17	7.1	1.392157	9.884314

Total power(P1) = 7.774474

Total Power(P2) = 13.12423

Total power output without tracking = 7.774474

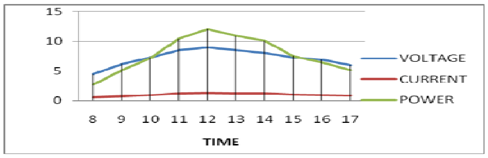
Total power output with tracking = 13.12423

Difference in power output = 5.349757

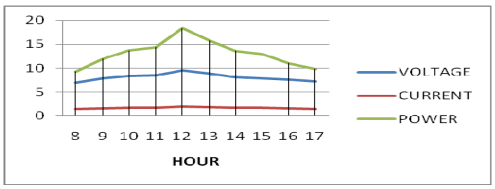
Efficiency of tracking = (13.12423 – 7.774474)/7.774474

Efficiency of tracking system = 68.88%

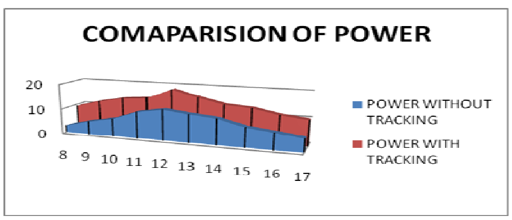
Result Analysis:Voltage,Current &Power vs Time(Without Tracking)



Result Analysis:Voltage,Current &Power vs Time(With Tracking)

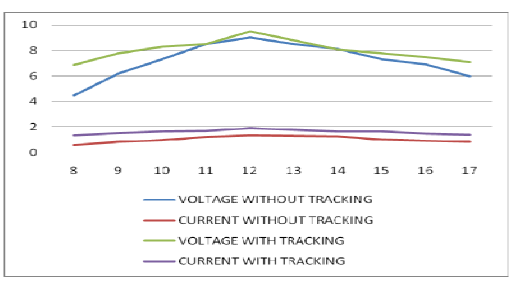


Result Analysis:Comparision of Power(With & Without Trackling)



Result Analysis:Comparision of Power(With & Without

Trackling)



Advantages

1. Solar tracking methods are used to continually orient photovoltaic panels in direction of the sun and might help maximize your investment in your PV system

2. They are beneficial because the sun's position within the sky will change gradually over the course of a day and over the seasons throughout the year.

3. They can be used most successfully in areas with low horizons and locations which are shade free from dawn to dusk every day.

4. IT is particularly significant through out the summer months with its long days of sunlight available to seize and when, at many Northern latitudes, the solar rises in the northeast and sets in the northwest, no energy will likely be lost.

5. For those with limited space which means a smaller array only needs to be installed, a huge advantage for those smaller sites with solely a small area to place equipment; they will be capable to produce most energy output but only have to utilize one of the smaller solar home systems.

Conclusion

India has emerged as the world number one alon with the united states in annual solar power generation.In wind power production india ranks fifth in the world,india ranks foruth in the world.Mckinsey & company,in its survey ended in may 2009,has stated that india has one of the worlds highest solar intensities with an annual soar energy yield of 1700 to 1900 kilowatt hours per kilowatt peak of the installed capacity.Besides solar and wind indias index for development of renewable energy resources in hydropower sector is the fourth top most in the world after GERMANY and CHINA.Similarly the countries like Italy,UK,FRANCE,CANADA and AUSTRALIA lag behind india in this world index. The Mckinsey report stated "This implies enormous potential in energy generation running into several hundred giga watts with current solar technologies.As the cost of building solar capcity continues to fall over the next five to 10years ,a significant scale up of solar generation is a very realistic possibility in india.

References:

Digital Electronics By: - Mr V.K.Mehta page-53

1. ***Non-Conventional Energy Resources By: - Mr B.H.Khan page-48***
   Mr G.D.Rai
   page-123
2. ***IETE Journals (December-2006)***
3. ***IETE Journals (August-2007)***
4. ***www.electronicsdynamic.com***
5. ***www.seeiccircuit2day.com***