LOW COST SOLAR TRACKER

MARLIYANI BINTI OMAR

This thesis is submitted as partial fulfillment of the requirements for the award of the
Bachelor of Electrical Engineering (Hons.) (Electronics)

Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

MAY, 2009

ACKNOWLEDGEMENT

I would like to thank first and most my supervisor, Mr.Mohd Shawal bin Jadin for his support and guidance in my final year project. He has provided me with great approaching and feedback every step of the way as a result of that I have learned and grown well. Sincerely thank for the greatly involved in the progress of this work with no tired. Also thank to my faculty of electrical and electronic to afford this project to student, through this I believe it well and really helped to gain the skill and knowledge. I also would like to thank other member especially my friends which supported me during the hard time. Thank you to all my friends for helping me and assisting me during the project development. This thesis would also not be possible without an assist from my supervisor. He has been great and supportive to keep me motivated to finish this thesis early. I would like to extend mine appreciate to my parent for always there for me.

ABSTRACT

Photovoltaic, or PV for short, is a technology in which light is converted into electrical power. One of the applications of PV is in solar tracker. A solar tracker is a device for operating a solar photovoltaic panel or concentrating solar reflector or lens forward sun-concentrates, especially in solar cell application, require high degree of accuracy to ensure that the concentrated sunlight is dedicated precisely to the power device. Solar tracker is invented because solar panel disables to move toward the sunlight when the sun moves from east to west. In order to produce maximum power output, solar tracker is design with motor so that the solar panel will move toward the position of sun. To control the solar panel so that it will always face the sun, the circuit has timer that consistent to the sun movement. The timer indicates the time to move solar panel in 12 hours. It moves the solar panel every one hour. It gives signal to the motor to move the solar panel. When the solar panel face directly to the sun and has maximum concentrated sunlight to the solar panel, the maximum power output will produce. The solar tracker is design as active tracker. It moves according to the sun movement and controlled by microcontroller. The solar tracker is design as low cost and easily to use. The solar tracker is design low cost due to the expensive of solar panel. To make sure to have enough demand electricity, we use more photovoltaic module. To decrease the cost, we use solar tracker. Besides that, this solar tracker use to save electricity in producing maximum power from solar panel because solar power is renewable energy.

ABSTRAK

Voltan cahaya, atau singkatannya PV ialah teknologi di mana cahaya ditukarkan kepada kuasa elektrik. Salah satu aplikasi PV ialah penjejak solar. Penjejak solar adalah satu alat untuk mengawal panel solar atau menumpukan pemantul sel solar atau kanta penumpu cahaya terutamanya dalam aplikasi solar sel, memerlukan darjah ketepatan yang tinggi untuk memastikan cahaya ditumpukan dengan lebih tepat ke arah panel solar. Penjejak solar di cipta kerana panel solar tidak boleh bergerak sendiri mengikut pergerakan matahari dari timur ke barat. Untuk memastikan supaya dapat menghasilkan maksimum keluaran kuasa, penjejak solar di reka dengan motor supaya penjejak solar boleh bergerak seiring dengan pergerakan matahari. Untuk mengawal pergerakan penjejak solar supaya sentiasa menghadap ke arah matahari, penjejak solar direka dengan pengawal masa supaya kedukan solar penjejak sentiasa konsisten dengan kedudukan matahari.. Pengawal masa mengawal penjejak solar untuk bergerak selama 12 jam. Ia menggerakkan panel setiap 1 jam. Ia memberi arahan kepada motor untuk bergerak. Bila panel solar menghadap terus ke matahari dan maksimum cahaya matahari tertumpu, maksimum keluaran kuasa akan dihasilkan. Penjejak solar direka sebagai penjejak aktif. Ia bergerak mengikut kedudukan matahari dan dikawal oleh pengawal terbenam. Penjejak solar direka sebagai rekaan yang murah dan senang digunakan. Untuk memastikan dapat memenuhi keperluan tenaga elektrik, kita perlu menggunakan lebih bayak modul solar. Oleh itu, untuk mengurangkankos, kite mggunakan penjejak solar. Selain itu, penjejak solar dapat menjimatkan elektrik dalam menghasilkan kuasa maksimum dari solar panel kerana kuasa solar ialah tenaga yang boleh diperbaharui.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

DC – direct current

PV – photovoltaic

PWM – pulse width modulation

CW – clockwise

CCW – counter clockwise

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter explains the overview on solar tracker and the significance of solar tracker. Overview on solar tracker explains briefly on what is the solar tracker and the functions of solar tracker. It also explains on the significance of solar tracker for the user and why the solar tracker is invented.

1.2 Overview On Solar Tracker

Photovoltaic, or PV for short, is a technology in which light is converted into electrical power. It is best known as a method for generating solar power by using solar cells packaged in photovoltaic modules, often electrically connected in multiples as solar photovoltaic arrays to convert energy from the sun into electricity. Photovoltaic modules are especially useful in situations where the demand for electrical power is relatively low and can be catered for using a low number of modules. One of the applications of PV module is solar tracker. A solar tracker is a device for operating a solar photovoltaic panel or concentrating solar reflector or lens forward sun-concentrates sunlight is dedicated precisely to the power device. Solar tracker is invented because solar panel disables to move toward the sunlight when the sun moves from east to west. In order to produce maximum power output, solar tracker is design with motor so that solar panel will move toward the position of sun and it works with sensors and microcontroller. Solar tracker has many types but in order to produce maximum power output, we use active trackers.

The demand of electricity increase year by year. There are new factories, houses, hotels and more buildings and activity that require electricity. As Malaysia is a development country, the electricity generator is cannot fully support the demand. In order to make sure the demand electricity is fully support, the solar power is used as the renewable energy. Photovoltaic (PV) modules are devices that cleanly convert sunlight into electricity and offer a practical solution to the problem of power generation in remote areas. They are especially useful in situations where the demand for electrical power is relatively low and can be catered for using a low number of modules. Running lights, a refrigerator, a television and heating the water in a small home example of tasks that a small array of solar modules can cope with.
As to increase the electricity, the solar tracker plays the role in producing electricity. The solar tracker tracks the sun and concentrates the maximum sunlight to the PV module to generate electricity. As the solar tracker is used, the electricity can be generating more then the usual amount electricity generate in year. It can cover the electricity demand so that the citizens can live better without electricity being cut off and it can cover critical situation when there are technical problem with main electric generator. Overall, the solar tracker is useful and has to be commercialized more.

1.3 Problem Statement

The Sun move from east to west. To collect maximum output power, the maximum intensity of light must be concentrated on solar panel. Solar panel is placed fixed and disables to move according to the sun movement thus the power output is lesser.

1.4 Objectives

The objectives of the project are:

(i) To track the sun so that the solar panel can produce maximum power output. The solar tracker will follow the sun movement to produce more output power.

(ii) To design low cost solar tracker that compatible for user so that users are affordable in order to use domestic solar panel more efficiently

1.5 Work scope

The work scope involve in this project are:

(i) The implementation of microcontroller in controlling the output of the project.

(ii) Choosing the suitable motor to control the angle of the solar panel so that it will always face to the sun.

(iii) Choosing the right method in deciding the angle direction of solar panel

1.6 Thesis Outline

Chapter 1 is discussing about the overview on solar tracker. It explains about the problem statement, objectives and work scope of the project.

Chapter 2 is discussing about the literature review. It explains the development of photovoltaic technology, the history of solar cell, and overview on the tracker types. Overall, it is about the basic knowledge on solar tracker.

Chapter 3 is discussing about the methodology that involves in designing the project. There are two sections. The first section discusses about the hardware implementation and the second section discuss about software development.

Chapter 4 is discussing about the result and discussion obtain from the testing the project. The result is basically on the operation of solar tracker and the prove that solar tracker can produce maximum power output.

Chapter 5 is discussed about the conclusion of the project. There are future recommendations of the project and the costing and commercialization of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Solar Power Development

Ancient Greeks and Romans saw great benefit in what we now refer to as passive solar design—the use of architecture to make use of the sun's capacity to light and heat indoor spaces. In 1861, Mouchout developed a steam engine powered entirely by the sun. But its high costs coupled with the falling price of English coal doomed his invention to become a footnote in energy history. Nevertheless, solar energy continued to intrigue and attract European scientists through the 19th century. Scientists developed large cone-shaped collectors that could boil ammonia to perform work like locomotion and refrigeration. France and England briefly hoped that solar energy could power their growing operations in the sunny colonies of Africa and East Asia. Solar power could boast few major gains through the first half of the 20th century, though interest in a solar-powered civilization never completely disappeared. In fact, Albert Einstein was awarded the 1921 Nobel Prize in physics for his research on the photoelectric effect—a phenomenon central to the generation of electricity through solar cells. In 1953, Bell Laboratories (now AT&T labs) scientists Gerald Pearson, Daryl Chapin and Calvin Fuller developed the first silicon solar cell capable of generating a measurable electric current. The New York Times reported the discovery as "the beginning of a new era, leading eventually to the realization of harnessing the almost limitless energy of the sun for the uses of civilization." [9]

In 1956, solar photovoltaic (PV) cells were far from economically practical. Electricity from solar cells ran about $300 per watt. (For comparison, current market rates for a watt of solar PV hover around $5.) The "Space Race" of the 1950s and 60s gave modest opportunity for progress in solar, as satellites and crafts used solar paneling for electricity. By the 1990s, the reality was that costs of solar energy had dropped as predicted, but costs of fossil fuels had also dropped—solar was competing with a falling baseline. However, huge PV market growth in Japan and Germany from the 1990s to the present has reenergized the solar industry. In 2002 Japan installed 25,000 solar rooftops. Such large PV orders are creating economies of scale, thus steadily lowering costs. The PV market is currently growing at a blistering 30 percent per year, with the promise of continually decreasing costs. Meanwhile, solar thermal water heating is an increasingly cost-effective means of lowering gas and electricity demand. [9]

2.2 Photovoltaic Technology

Photovoltaic are best known as a method for generating electric power by using solar cells packaged in photovoltaic modules, often electrically connected in multiples as solar photovoltaic arrays to convert energy from the sun into electricity. To explain the photovoltaic solar panel more simply, photons from sunlight knock electrons into a higher state of energy, thereby creating electricity. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy. Virtually all photovoltaic devices are some type of photodiode. Solar cells produce direct current electricity from light, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaic was to power orbiting satellites and other spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation. In this case an inverter is required to convert the DC to AC. There is a smaller market for off grid power for remote dwellings, roadside emergency telephones, remote sensing, and cathodic protection of pipelines.[8]

2.3 Solar Panel

In the field of photovoltaic, a photovoltaic module or photovoltaic panel is a packaged interconnected assembly of photovoltaic cells, also known as solar cells. An installation of photovoltaic modules or panels is known as a photovoltaic array. Photovoltaic cells typically require protection from the environment. For cost and practicality reasons a number of cells are connected electrically and packaged in a photovoltaic module, while a collection of these modules that are mechanically fastened together, wired, and designed to be a field-installable unit, sometimes with a glass covering and a frame and backing made of metal, plastic or fiberglass, are known as a photovoltaic panel or simply solar panel.[2]

2.4 Solar Tracker Fundamentals

A solar tracker is a device for orienting a day lighting reflector, solar photovoltaic panel or concentrating solar reflector or lens toward the sun. The sun's position in the sky varies both with the seasons (elevation) and time of 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. There are many types of solar trackers, of varying costs, sophistication, and performance. One well-known type of solar tracker is the heliostat, a movable mirror that reflects the moving sun to a fixed location, but many other approaches are used as well. The required accuracy of the solar tracker depends on the application. Concentrators, especially in solar cell applications, require a high degree of accuracy to ensure that the concentrated sunlight is directed precisely to the powered device, which is at (or near) the focal point of the reflector or lens. Typically concentrator systems will not work at all without tracking, so at least single-axis tracking is mandatory. Very large power plants or high temperature materials research facilities using multiple groundmounted mirrors and an absorber target require very high precision similar to that used for solar telescopes.

Non-concentrating applications require less accuracy, and many work without any tracking at all. However, tracking can substantially improve both the amount of total power produced by a system and that produced during critical system demand periods (typically late afternoon in hot climates) The use of trackers in non-concentrating applications is usually an engineering decision based on economics. Compared to photovoltaics, trackers can be inexpensive. This makes them especially effective for photovoltaic systems using high-efficiency (and thus expensive) panels. Although trackers are not a necessary part of a P.V system, their implementation can dramatically improve a systems power output by keeping the sun in focus throughout the day. Efficiency is particularly improved in the morning and afternoon hours where a fixed panel will be facing well away from the suns rays. Usually, photovoltaic modules are expensive and in most cases the cost of the modules themselves will outweigh the cost of the tracker system. Additionally a well designed system which utilizes a tracker will need less panels due to increased efficiency, resulting in a reduction of initial implementation costs. [3]

2.5 Overview on Tracker Mount Types

Solar trackers may be active or passive and may be single axis or dual axis. Single axis trackers usually use a polar mount for maximum solar efficiency. Single axis trackers will usually have a manual elevation (axis tilt) adjustment on a second axis which is adjusted on regular intervals throughout the year. Compared to a fixed mount, a single axis tracker increases annual output by approximately 30%, and a dual axis tracker an additional 6%. There are two types of dual axis trackers, polar and altitude-azimuth. [6]

2.6 Polar

Polar trackers have one axis aligned to be roughly parallel to the axis of rotation of the earth around the north and south poles-- hence the name polar. (With telecopes, this is called an equatorial mount.) Single axis tracking is often used when combined with time-of-use metering, since strong afternoon performance is particularly desirable for grid-tied photovoltaic systems, as production at this time will match the peak demand time for summer season air-conditioning. A fixed system oriented to optimize this limited time performance will have a relatively low annual production. The polar axis should be angled towards due north, and the angle between this axis and the vertical should be equal to your latitude.

Simple polar trackers with single axis tracking may also have an adjustment along a second axis: the angle of declination. It might be set with manual or automated adjustments, depending on your polar-tracking device. If one is not planning on adjusting this angle of declination at all during the year, it is normally set to zero degrees, facing your panel straight out perpendicular to the polar axis, as that is where the mean path of the sun is found. Occasional or continuous adjustments to the declination compensate for the northward and southward shift in the sun's path through the sky as it moves through the seasons (and around the ecliptic) over the course of the year. [7]

Figure2.1 Polar tracker

2.7 Horizontal Axle

Several manufacturers can deliver single axis horizontal trackers which may be oriented by either passive or active mechanisms, depending upon manufacturer. In these, a long horizontal tube is supported on bearings mounted upon pylons or frames. The axis of the tube is on a North-South line. Panels are mounted upon the tube, and the tube will rotate on its axis to track the apparent motion of the sun through the day. Since these do not tilt toward the equator they are not especially effective during winter mid day (unless located near the equator), but add a substantial amount of productivity during the spring and summer seasons when the solar path is high in the sky. These devices are less effective at higher latitudes. The principal advantage is the inherent robustness of the supporting structure and the simplicity of the mechanism. Since the panels are horizontal, they can be compactly placed on the axle tube without danger of self-shading and are also readily accessible for cleaning. [7]

Figure 2.2 Horizontal axle of solar tracker

2.8 Two Axes Mount Type

Restricted to active trackers, this mount is also becoming popular as a large telescope mount owing to its structural simplicity and compact dimensions. One axis is a vertical pivot shaft or horizontal ring mount that allows the device to be swung to a compass point. The second axis is a horizontal elevation pivot mounted upon the azimuth platform. By using combinations of the two axes, any location in the upward hemisphere may be pointed. Such systems may be operated under computer control according to the expected solar orientation, or may use a tracking sensor to control motor drives that orient the panels toward the sun. This type of mount is also used to orient parabolic reflectors that mount a Stirling engine to produce electricity at the device. [7]

Figure 2.3 Two axes mount type solar tracker

2.9 Overview of current driver tracker types

Solar trackers can be divided into three main types depending on the type of drive and sensing or positioning system that they incorporate. Passive trackers use the suns radiation to heat gasses that move the tracker across the sky. Active trackers use electric or hydraulic drives and some type of gearing or actuator to move the tracker. Open loop trackers use no sensing but instead determine the position of the sun through pre recorded data for a particular site. [1]

2.10 Gas Trackers (Passive Trackers)

Passive trackers use a compressed gas fluid as a means of tilting the panel. A canister on the sun side of the tracker is heated causing gas pressure to increase and liquid to be pushed from one side of the tracker to the other. This affects the balance of the tracker and caused it to tilt. This system is very reliable and needs little maintenance. Although reliable and almost maintenance free, the passive gas tracker will very rarely point the solar modules directly towards the sun. This is due to the fact that temperature varies from day to day and the system can not take into account this variable. Overcast days are also a problem when the sun appears and disappears behind clouds causing the gas in the liquid in the holding cylinders to expand and contract resulting in erratic movement of the device. Passive trackers are however an effective and relatively low cost way of increasing the power output of a solar array. The tracker begins the day facing west. As the sun rises in the east, it heats the unshaded west-side canister, forcing liquid into the shaded east-side canister. The liquid that is forced into the east side canister changes the balance of the tracker and it swings to the east. It can take over an hour to accomplish the move from west to east.

The heating of the liquid is controlled by the aluminum shadow plates. When one canister is exposed to the sun more than the other, its vapor pressure increases, forcing liquid to the cooler, shaded side. The shifting weight of the liquid causes the rack to rotate until the canisters are equally shaded. The rack completes its daily cycle facing west. It remains in this position overnight until it is "awakened" by the rising sun the following morning. [1]

Figure 2.4 Passive tracker

2.11 Active Trackers

Active trackers measure the light intensity from the sun to determine where the solar modules should be pointing. Light sensors are positioned on the tracker at various locations or in specially shaped holders. If the sun is not facing the tracker directly there will be a difference in light intensity on one light sensor compared to another and this difference can be used to determine in which direction the tracker has to tilt in order to be facing the sun. [1]

Figure 2.5 Active solar tracker

2.12 Open loop trackers

Open loop trackers determine the position of the sun using computer controlled algorithms or simple timing systems. Timed Trackers – these use a timer to move the tracker across the sky. Incremental movement throughout the day keeps the solar modules facing the general direction of the sun. Trackers of this type can utilize one or two axes depending on their application and the price that the buyer is willing to pay. The main disadvantage of timed systems is that their movement does not take into account the seasonal variation in sun position. Unless measures are taken to adjust the tracker position seasonally there will be a noticeable difference in efficiency depending on the season.