DESIGN OF SUN TRACKER FOR A PV SYSTEM

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APPROVAL PAGE

This project has been duly supervised and approved as having partially fulfilled the requirements for the award of degree of Bachelor of Science Physics of the UsmanuDanfodiyo University, Sokoto.

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DEDICATION

This research project is dedicated to Almighty Allah (S.W.A) who created mankind and taught mankind what he knew not. And also dedicated to my parent, brothers, friends, and my supervisor.

ACKNOWLEDGEMENT

I must begin by expressing my sincere gratitude and thank to the Most High Allah for his grace and Infinite mercy for protecting and guiding me throughout this period of training and granting me this opportunity to learn and pursue this project report with sound health and knowledge.

I wish to express my profound gratitude to my supervisor Professor Musa Momoh, who bears with patience and understanding the burden of supervising this work. Sir I tender my sincere gratitude.

My humble gratitude to my father in person AlhajiAbdullahi .N. Muhammad, my mother, brothers, sisters and friends etc. for their contribution, care and love. May Allah bless you all.

Finally, whatever shortcoming found in this study is my sole responsibility and I seek Allah's forgiveness for this because I am fallible.

ABSTRACT

This project involves a design of sun tracker for PV system.

The circuit of the sun tracker is designed in such a way that it follows the track of the sun as it travel in the sky. The LDR are connected to non-inverter input of the operational amplifier whose reference voltage resistor R1 and R2 is 10Ω each. At the output of the operational amplifier are NPN and PNP transistor. These transistors are used to drive the DC motor in forward and backward directions which corresponds to the direction of the sun in the sky. The motor is switch through a relay.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

A solar tracker is a device for orienting a photovoltaic array 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, sophisticationand performance. One well-known type of solar tracker is the heliostat, a movable mirror that reflects the moving sun to a fixed location. (Pang 2010). But many other approaches are used as well 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 photo voltaic, trackers can be inexpensive. This makes theme especially effective for photovoltaic systems using high-efficiency (and thus expensive) panels.

1.2 STATEMENT OF THE PROBLEM

While the output of solar cells depends on the intensity of sunlight and the angle of incidence, it means to get maximum efficiency; the solar panels must remain in front of sun during the whole day. But due to rotation of earth those panels can't maintain their position always in front of sun. This problem results in decrease of their efficiency. Thus to get a constant output, an automated system is required which should be capable to constantly rotate the solar panel. The Solar Tracking System is made as a prototype to solve the problem, mentioned above. It is completely automatic and keeps the panel in front of sun where we get the maximum output.

1.3 AIMS AND OBJECTIVES

The major aim of this project work is to design a sun tracker that follows through the sun as it moves in the sky.The basic target of this project is to provide the means of solving some existing problems in real life activities of man in order to create simplicity in human's life. The objective involve, providing simple means of controlling the movement of a device that would follow the sun as it move in the sky. This project is very important in the sense that can be used in application like solar dryer and similar one's that needs the presence. The circuit uses very simple design approach which makes the work very effective in its operation and of course, cost effective. The entire components used in this design circuit are commonly available.

1.4 SOLAR TIME

Solar time (t s) is based on the 24 hour clock, with 12h00 as solar noon (the time that the Sun is exactly due south - in northern hemisphere, or due north - in the southern hemisphere). The concept of solar time is used in predicting the direction of sunrays relative to a point on the Earth. Solar time is location (longitude) dependent and is generally different from local clock time (LCT), which is defined by politically defined time zones and other approximations. The conversion between solar time and local clock time requires knowledge of the location, the day of the year, and the local standards to which local clocks are set.

1.5 SIGNIFICANCE OF THE WORK

This project, design of a sun tracker for PV system would be very significant to the people due to its functions. In the first place the project would be very important in providing means of solving the problems of drying substances using sun. It would also help by saving people from doing the manual work of changing the directions of dryers. Another significance of this work is that it is very cheap in such a way that almost everybody can afford to get it.

1.6SCOPE OF THE PROJECT

The scope of this project, design of sun tracker is basically the design of the different parts of the circuit, it involves; design work to verify the workability and making any required adjustment

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

In order to understand how to collect energy from the Sun, it is imperative to predict the relation between the Sun's and the collection device's locations. Therefore, it is necessary to know the solar dynamics and the key indicators that define the relative positions of the Sun and the Earth.

Extracting usable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of the solar cell. A semi conductive material that converts visible light into a direct current by using solar arrays, are series of solar cells electrically connected, a DC voltage is generated which can be physically used on a load. Solar arrays or panels are being used increasingly as efficiencies reach higher levels, and are especially popular in remote areas where placement of electricity lines is not economically viable. Sunlight is made up of packets of energy called photons (Pang, 2010). When the photons strike the semi-conductor layer (usually silicon) of a solar cell a portion of the photons are absorbed by the material rather than bouncing off of it or going through the material. When a photon is absorbed the energy of that photon is transferred to an electron in an atom of the cell causing the electron to escape from its normal position. This creates, in essence hole in the atom. This hole will attract another electron from a nearby atom now creating yet another hole, which in turn is again filled by an electron from another atom(Pang, 2010).One of the problems with solar power is that the output of the solar panel is variable. These solar systems are designed to extract the maximum amount of power available from the solar panels and deposit it in the battery.

2.2 SOLAR CELL

A solar cell is an electronic device which directly converts sunlight into electricity. Light shining on the solar cell produces both a current and a voltage to generate electric power. This process requires firstly, a material in which the absorption of light raises an electron to a higher energy state, and secondly, the movement of this higher energy electron from the solar cell into an external circuit, (King, Boyson, and Kratochvil, 2002). The electron then dissipates its energy in the external circuit and returns to the solar cell. A variety of materials and processes can potentially satisfy the requirements for photovoltaic energy conversion, but in practice nearly all photovoltaic energy conversion uses semiconductor materials in the form of a *p-n* junction.

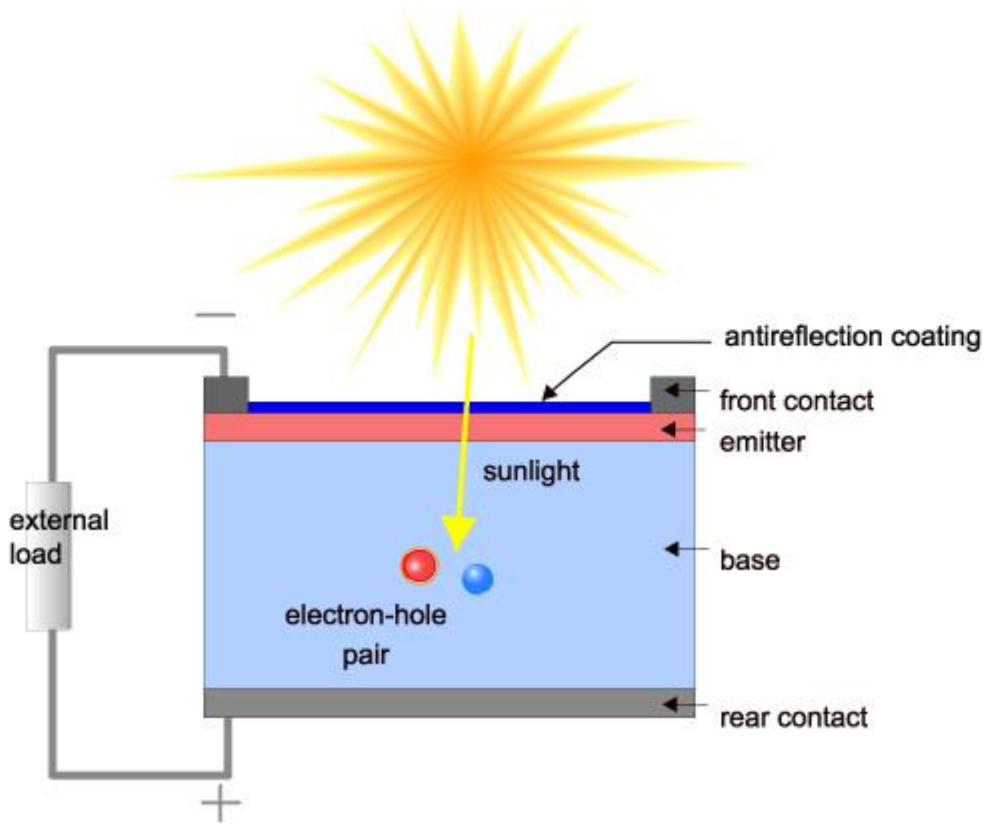


Figure 2.1 Cross section of a solar cell(King, etal 2002).

The basic steps in the operation of a solar cell are:(King, etal 2002).

- The generation of light-generated carriers;
- The collection of the light-generated carries to generate a current;
- The generation of a large voltage across the solar cell; and
- The dissipation of power in the load and in parasitic resistances.

2.3 SOLAR PANEL

A solar cell, sometimes called a photovoltaic cell, is a device that converts light energy into electrical energy. A single solar cell creates a very small amount of energy (about 6 volts DC) so they are usually grouped together in an integrated electrical panel called a solar panel. Sunlight is a somewhat diffuse form of energy and only a portion of the light captured by a solar cell and converted into electricity. Sunlight is made up of packets of energy called photons.When the photons strike the semi-conductor layer (usually silicon) of a solar cell a portion of the photons are absorbed by the material rather than bouncing off of it or going through the material. When a photon is absorbed the energy of that photon is transferred to an electron in an atom of the cell causing the electron to escape from its normal position. This creates in essence, a hole in the atom. This hole will attract another electron from a nearby atom now creating yet another whole, which in turn is again filled by an electron from another atom. (Cemil, 2009)

2.4TYPES OF SOLAR PANEL

i. **MONO CRYSTALLINE**

Figure 2.2Mono crystalline solar panel. (Arif and Sumathy, 2010).

Mono crystalline solar panels are made from a large crystal of silicon. These types of solar panels are the most efficient as in absorbing sunlight and converting it into electricity; however they are the most expensive. They do somewhat better in lower light conditions then the other types of solar panels.(Arif and Sumathy, 2010).

ii. **POLYCRYSTALLINE:**

Figure 2.3 Polycrystalline Photovoltaic Solar Panel. (Arif and Sumathy, 2010).

Polycrystalline solar panels are the most common type of solar panels on the market today. They look a lot like shattered glass. They are slightly less efficient than the mono crystalline solar panels and less expensive to produce, (Arif and Sumathy, 2010).Instead of one large crystal, this type of solar panel consists of multiple amounts of smaller silicon crystal, (Arif and Sumathy, 2010).

iv. **AMORPHOUS SOLAR PANELS**

Figure 2.4 Amorphous Silicon "Thin Film" Photovoltaic Solar Panel, (Arif and Sumathy, 2010).

Amorphous solar panels consist of a thin-like film made from molten silicon that is spread directly across large plates of stainless steel or similar material. These types of solar panels have lower efficiency than the other two types of solar panels, and the cheapest to produce. One advantage of amorphous solar panels over the other two is that they are shadow protected. That means that the solar panel continues to charge while parts of the solar panel cells are in a shadow, (Arif and Sumathy, 2010).

Solar cells have many applications. Individual cells are used for powering small devices such as electronic calculators.

Photovoltaic arrays generate a form of renewable electricity, particularly useful in situations where electrical power from the grid is unavailable such as in remote area power systems, Earth-orbiting satellites and space probes, remote radiotelephones and water pumping applications. (Arif and Sumathy, 2010).

2.5 SUN TRACKER

A solar tracker is a device that orients a payload toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices (Pang (2010).

In flat-panel photovoltaic (PV) applications, trackers are used to minimize the angle of incidence between the incoming sunlight and a photovoltaic panel(Pang, 2010). This increases the amount of energy produced from a fixed amount of installed power generating capacity. In standard photovoltaic applications, it was predicted in 2008-2009 that trackers could be used in at least 85% of commercial installations greater than 1MW from 2009 to 2010. However, as of April 2014, there is not any data support these predictions (Pang, 2010).

In concentrated photovoltaic (CPV) and concentrated solar thermal (CSP) 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 sunlight and therefore must be oriented appropriately to collect energy. Tracking systems are found in all concentrator applications because such systems do not produce energy unless pointed at the sun(Pang, 2010).

2.6 TYPES OF SUN TRACKER

Tracking systems are found in all concentrator applications because such systems do not produce energy unless pointed at the sun.

More energy is collected by the end of the day if the pv module is installed on a tracker, with an actuator that follows the sun (Pang, 2010). There are two types of sun trackers.

i. ACTIVE TRACKER

Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Active two-axis trackers are also used to orient heliostats - movable mirrors that reflect sunlight toward the absorber of a central power station(Pang (2010). As each mirror in a large field will have an individual orientation these are controlled programmatically through a central computer system, which also allows the system to be shut down when necessary(Pang, 2010).

ii. PASSIVE TRACKER

Passive trackers use a low boiling point compressed gas fluid that is driven to one side or the other (by solar heat creating gas pressure) to cause the tracker to move in response to an imbalance. As this is a non-precision orientation it is unsuitable for certain types of concentrating photovoltaic collectors but works fine for common PV panel types. These will have viscous dampers to prevent excessive motion in response to wind gusts.

Shadier/reflectors are used to reflect early morning sunlight to "wake up" the panel and tilt it toward the sun, which can take nearly an hour. The time to do this can be greatly reduced by adding a self-releasing tie down that positions the panel slightly past the zenith (so that the fluid does not have to overcome gravity) and using the tie down in the evening(Pang, 2010).

2.7PHYSICS RELATED THEORY

TRANSISTOR AND ITS APPLICATION

The transistor is generally an active component and solid state form which is very useful in today electronics technology. Transistor as an electronics component can be applied in the three basic ways. Firstly, the transistor can be used as oscillating device which can produce both the audio frequency and the radio frequency.

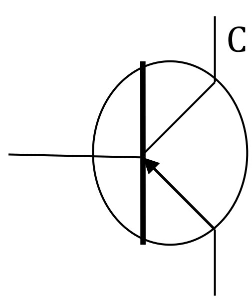
Secondly, the transistor can be used for amplification. It can amplify both the signals of audio and radio frequency(Bosi and Pelosi, 2007).

Finally the transistor is used as an electronic switch in many applications. The most commonly used transistor now is called the bipolar junction transistor (BJT). The device is a three – terminal device in nature(Bosi and Pelosi, 2007).

The terminal are called the base (B) the collector (C) and the emitter (E)

The BJT transistor can be either NPN or PNP in nature as shown in figure below

NPN stands for negative-position-negative transistor which as shown below



B

E

Figure 2.5PNP transistor(Bosi and Pelosi, 2007).

There is also another type of transistor which is as common as the BJT. This types of transistor is called field effect transistor which is as common as the BJT. This type of transistor is called field effect transistor (FET). It is also a device with three terminals(Bosi and Pelosi, 2007).

The terminals are the gate (G) the source (S) the Drain (D) as shown below

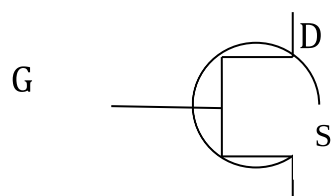


Figure 2.6 field effect transistors (Bosi and Pelosi, 2007).

The BJT transistor operates in three basic configurations.

They are common base, common collector and common emitter configurations. The choice of a particular configuration depends on the application. The FET also can operate. In the either enhanced mode or depletion mode as the case may be (Bosi and Pelosi, 2007).

2.8 OPERATIONAL AMPLIFIER

An operational amplifier or op-amp is an electronic circuit modules, which has a non-inverting input(+), an inverting input (-) and one output

Originally, op-amps were so named because they were used to model the basic mathematics operations addition, subtraction, integration, differentiation etc in electronic analogue computer. In this sense a true operational amplifier is an ideal circuit element(Bosi and Pelosi, 2007).

A typical circuit symbols for an op-amp is shown in figure 2.7

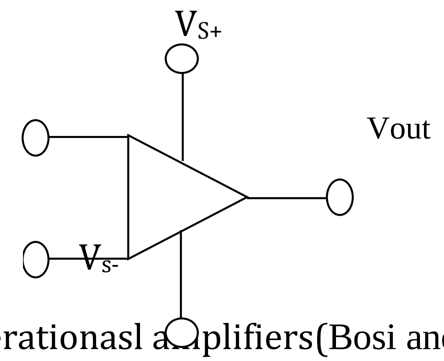


Figure 2. Operationasl amplifiers(Bosi and Pelosi, 2007).

Its terminal are: non-inverting input V_+ inverting input: output V_{out} positive power supply V_s+ negative power supply$V_{s-.s}$(Nayak and Pradhan, 2012).

CHAPTER THREE

SYSTEM DESIGN

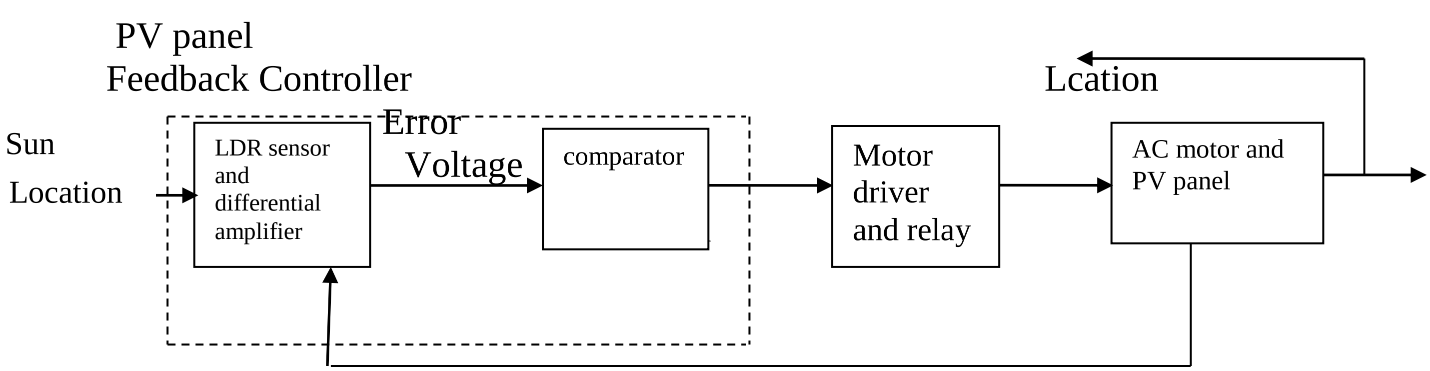
3.1 INTRODUCTION

In this chapter the basic design of the system is carried out. The general circuit diagram of the sun tracker presented together with its principle of operation, then the basic calculation for the design of the circuit below:

3.2 GENERAL BLOCK DESIGNS

Figure 3.1 described the composition and interconnection of the system for the sun tracking approach. The solar tracking problem is how to cause the PV panel location (output) to follow the sunlight location (input) as closely as possible. The sensor based feedback controller consists of the LDR sensor, differential amplifier and comparator. In the tracking operation, the LDR sensor measures the sunlight intensity as a reference input signal. The unbalance in voltages generated by the LDR sensor is amplified and then generates a feedback error voltage. The error voltage is proportional to the difference between the sunlight location and the PV panel location. At this time the comparator compares the error voltage with a specified threshold (tolerance). If the comparator output goes to high state, the motor driver and a relay are activated so as to rotate the dual axis (azimuth and elevation) tracking motor and bring the PV panel to face the sun accordingly.(Nayak and Pradhan, 2012).

The feedback controller performs the vital function; PV panel and sunlight are constantly monitored and send a differential control signal to drive the PV panel until the error voltage is less than a pre-specified threshold value. (Nayak and Pradhan, 2012).



s

Feedback

Figure 3.1 Block diagram of the solar tracking system.(Nayak and Pradhan, 2012).

3.3 UNIT DESIGN OF SUN TRACKER

Figure 3.2 depicts the developed solar photovoltaic system design and its modules. In module (A), a sensors system is designed to track the sun's position. In module (B), a linear actuator system is designed to drive the photovoltaic panel. In module (C), a tracking mechanism is designed to hold the photovoltaic panel and allows it to perform two-axis hemispheroidal rotation. Module (D) consists of a battery storage system and charge controller. They are designed to efficiently store the energy generated by the photovoltaic panel. In module (E), a microcontroller system is designed to automatically control the operation of the solar photovoltaic system. Figure 3.2 further shows a photo of the developed system.(Baltas, Tortoreli and Russel, 1986).

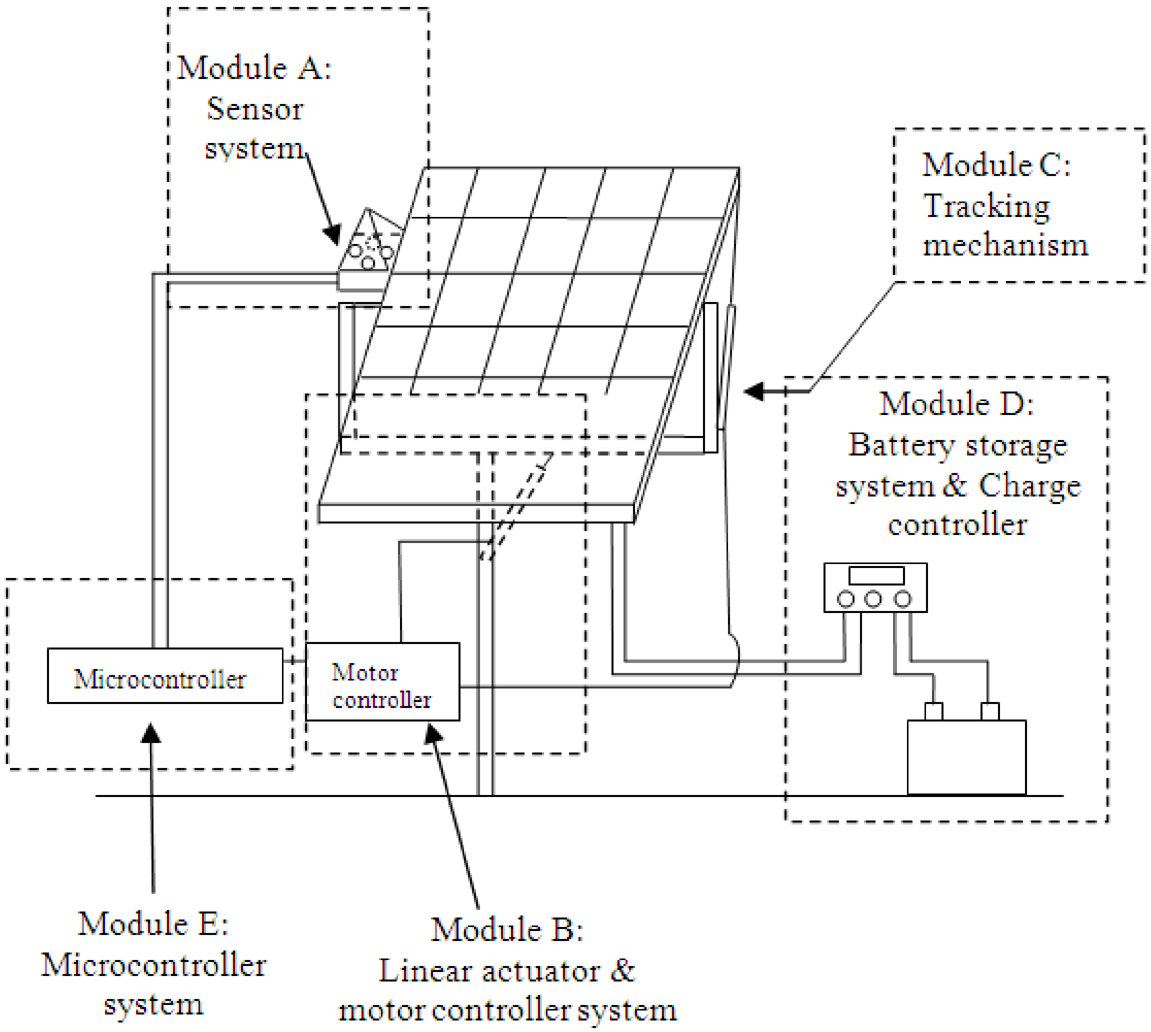


Figure 3.2 The block design of sun tracker. (Baltas, Tortoreli and Russel, 1986).

3.4 THE SENSORS SYSTEM

Figure 3.3 shows the developed module (A): a solar sensors system. This module is used to detect the direction of the light. It consists of four light dependent resistors (LDRs), i.e., east, west, south and north LDRs, which are fixed into a pyramidal block. When the sun is located on the center of the system, these LDRs will receive same amount of light intensity and hence produces the same resistance. However, when the sun is shifted, the cardboard placed in between these LDRs will produce shadow and this causes different light intensity to be received by these LDR sensors. We attempt to adjust the photovoltaic panel is such that resistance for east and west LDRs, and north and south LDRs are equal.(Lee, Chou, Chiang, and Lin, 2009).

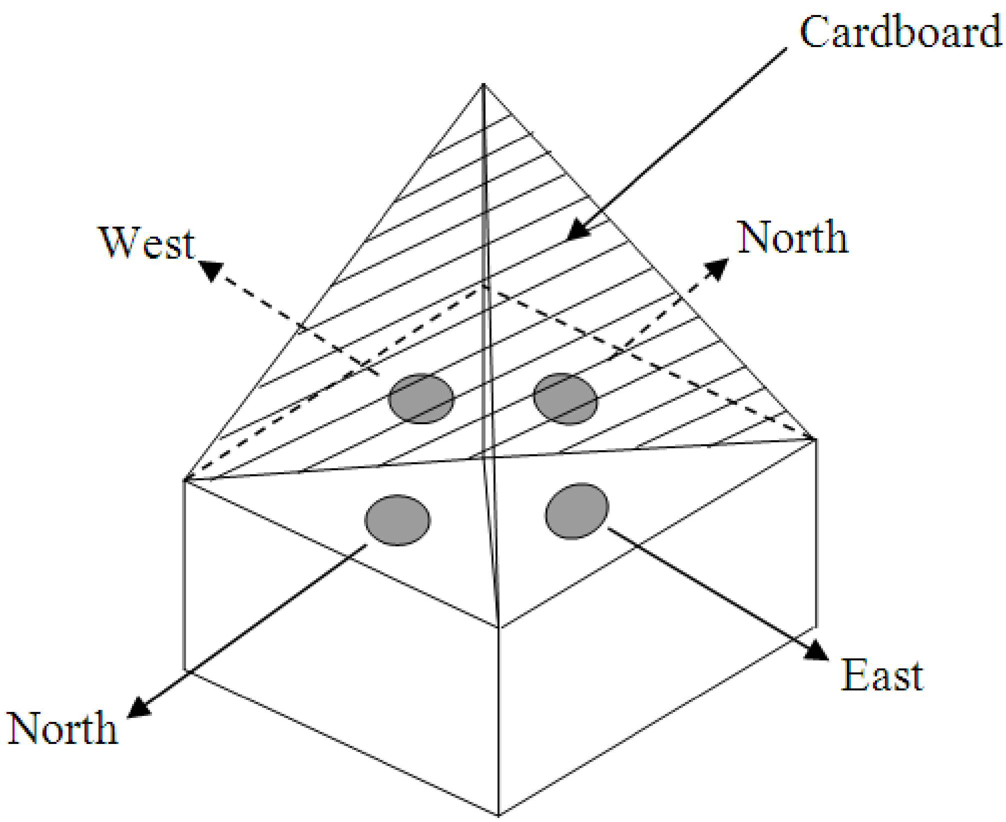


Figure 3.3 The sensor system design. (Lee, Chou, Chiang and Lin, 2009).

3.5 THE LINEAR ACTUATOR SYSTEM AND THE MOTOR CONTROLLER SYSTEM

Figure 3.4 depicts module (B), i.e., a linear actuator system and a motor controller system. The function of the linear actuator system is to drive the photovoltaic panel to the desire direction. The linear actuator consists of a built in DC Motor. The DC Motor is used to allow a smooth and precise extension along the sun tracking process. The motor controller is designed to receive signal from microcontroller to control the position of linear actuator in either to hold, extend or vice versa.(Shen, Tsai, 2007).

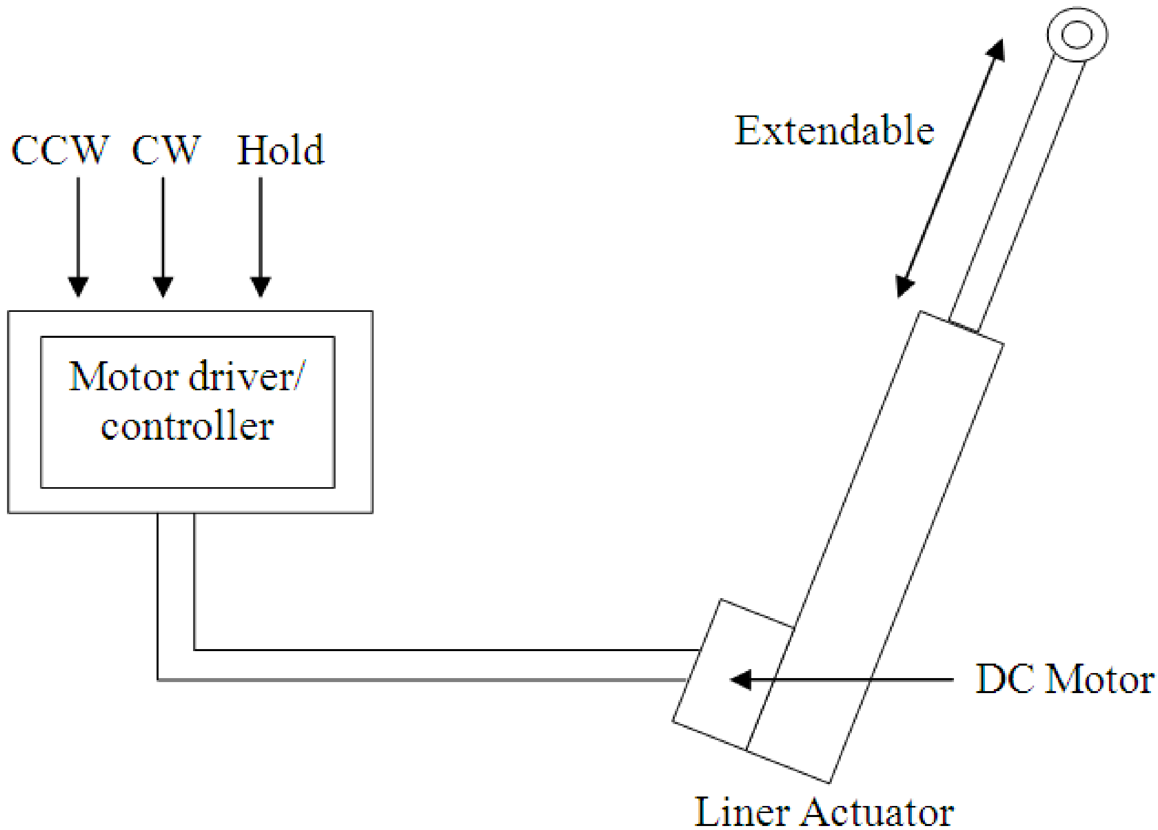


Figure 3.4 The linear actuator and motor controller system.(Shen, Tsai, 2007).

3.6 THE BATTERY STORAGE SYSTEM AND THE CHARGER CONTROLLER

Figure 3.5 illustrates the connection for module (D), i.e., battery storage and a charger controller system. The battery, the photovoltaic panel and the load are interconnected via a charger controller. For a brighter sunlight, more voltage would be produced from the photovoltaic panel and the excessive voltage could damage the battery. The charger controller is used to ensure the proper chsarging for the battery. While there is a load, charger controller gives priority to the load by switching off the charging. (Cemil, 2009).

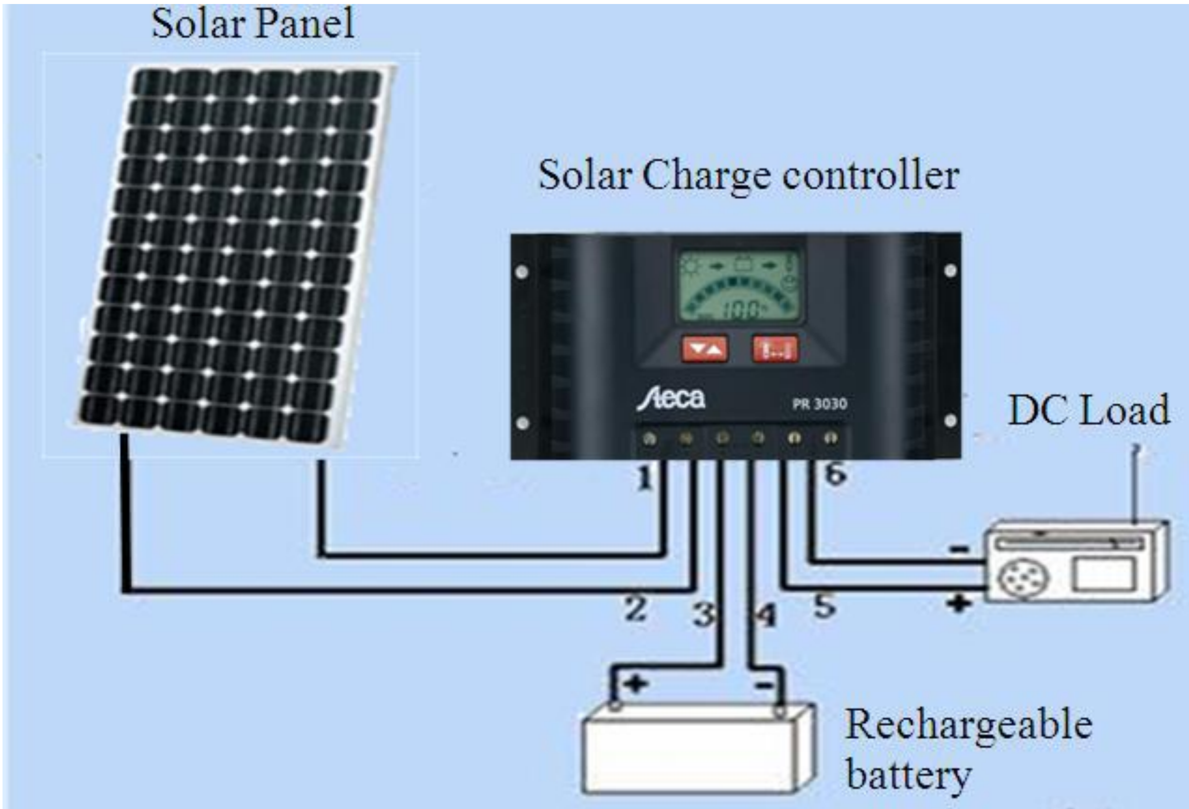


Figure 3.5 battery storage and charger controller.(Cemil, 2009).

3.7 THE MICROCONTROLLER SYSTEM AND THE DEVELOPED FLOWCHART

In this project, a microcontroller, i.e., PIC16F88 is implemented. Figure 3.6 illustrates the flowchart for our developed system.(Shen and Tsai, 2012). The sun’s intensity from four different directions is measured by the sensors system, i.e., the east, west, south and north LDRs. For the Y-axis, resistance for south and north LDRs are compared, and a signal is sent to the microcontroller to determine the sun’s position for the Y-axis. From this signal, the microcontroller will make a decision and send an instruction to motor controller, i.e., either to remain the position of the actuator, to extend the actuator or to shorten the actuator. If the resistances for these LDRs are not equal, the tracking process would proceed until the same resistances are obtained. The same goes to X-axis.(Shen and Tsai, 2012).

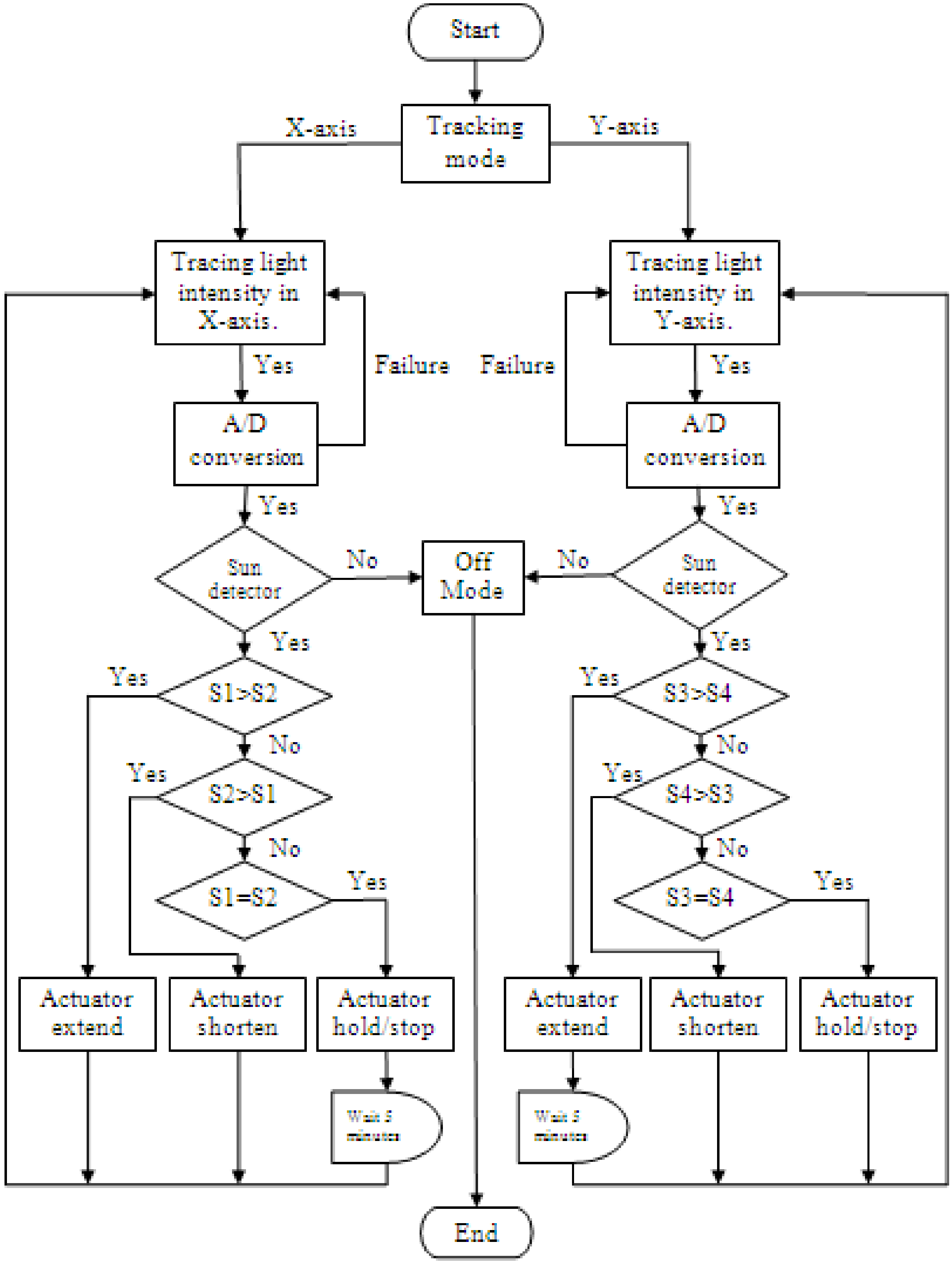


Figure 5.6 the microcontroller system and the developed flowchart. (Shen and Tsai, 2012).

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

CONCLUSION

In this project, the automatic solartracking system which is an efficient system, can beutilized anywhere such as house-hold purpose, inoffices, even in various industrial applications. Today`sworld is facing acute energy crisis.

It is necessary tofind new resources of energy and also need to improve the efficiency of power generation from otherrenewable energy sources to possible extent.

RECOMMENDATION

After predicting that which position orsituation of solar panels is most efficient, we willfollow this concept and we will present the optimizeduse procedure for the solar energy in very easilymanner. The system is able to track and follow Sunlightintensity in order to collect maximum solar powerregardless of motor speed. This can be used for all thetime by including external supply in case of emergencysuch as rainy season & bad weather conditions. Solarpanel tracking can be used for other applications suchas industrial parameter control, home automation, andmany more applications with slight modifications in theblock diagram. The constructed system model can beapplied in the residential area for alternative electricity generation especially for non-critical and low powerappliances.

The proposed methodology is an innovation so far. It achieves the following attractive features: (1) a stand-alone PV inverter to power the entire system, (2) ability to move the two axes simultaneously within their respective ranges, (3) ability to adjust the tracking accuracy, and (4) applicable to moving platforms with the Sun tracker. The empirical findings lead us to believe that the research work may provide some contributions to the development of solar energy applications.

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