2-AXIS SOLAR TRACKER MODEL

BY

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DECLARATION OF ORIGINALITY

I declare that this report entitled “2-AXIS SOLAR TRACKER” is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature: __________________________

Name: Ali AbdelDahhym

Date: 18/7/2013
DEDICATION

To my parents, for their overwhelming care and love ...
To my siblings, To my teachers, To my friends and colleagues ...
Acknowledgement

Thanks TO:

GOD the almighty for giving me health and power to finish this dissertation...

My supervisor DR. Ali Omer Ahmed who offered valuable comment and advices throughout the conduction of the project

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Thanks are extended to my colleague Rehab Elrashid, who Participate in the accomplishment of this thesis from the Very beginning up to end

To my friends
Abstract

Solar energy is rapidly gaining noticeable place as an important means of expanding renewable energy resources. This project includes the design and construction of a microcontroller-based solar panel tracking system. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun.

In this project, we are going to control the two-axis solar tracker for ensuring that panel will always face the sun. To achieve this goal we designed a circuit with two pairs of light sensors as an input and to stepper motor as an output. One motor will be moving East-West direction, the other will be moving North-South direction, and this motion is according to the difference in sensors pairs reading. Because of this, the panel will move along the day following the sun. When the solar panel is directly facing the sun and has maximum concentrated sunlight, the maximum power output will be produced.

The Dual-Axis solar tracker designed successfully and this project shows a clear benefit over both immobile and single-axis tracking systems.
المستخلص

تكتسب الطاقة الشمسية مكانة مهمّة، باعتبارها مصدّرًا لإتاحة موارد الطاقة المتاحة. يتضمن هذا المشروع تصميم وإنشاء نظام لتغذية مياه شمسية متكاملة، سواء بمسح نظام التّناغم الشمسي لإنتاج طاقة أكبر بسبب جعل لوحة الشمسية ذاتية موارد للشمس.

في هذا المشروع سوف تقوم بالتحكم في المتعادل ثنائي المحور وذلك من أن اللوحة مواجهة الشمس طوال الوقت. وتوصيل لهذا الهدف فيها تصميم دائرة كهربائية ذات رؤوس من الحساسات الضوئية داخل زوجين preconditioner. أحد المحرّرين سوف يحرك اللوحة في الاتجاه الشمالي الشرقي. والآخر سوف يحركها في الاتجاه الشمالي الغربي، بينما تتحرك المهندس في قرارات السهولة، كنيرة لإنهاء سلسلة تتحرك اللوحة طوال اليوم مثبتة للشمس. عندما تكون اللوحة الشمسية في وضع مواجهة مباشرة للشمس تنعكس على أعلى تركيز من شعاع الشمس من ذلك تتحصل على أعلى خرج للقدرة الكهربائية.

المتعادل ثنائي المحور يتم تصميمه بنجاح وهذا المشروع أثبت فائضه على نظام اللوحة الثالثة ونظام التّناغم احادي المحور.
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ABBREVIATIONS

PV
PV panels

Photovoltaic
Photovoltaic panels

DC

Direct current

HSAT
Horizontal single axis trackers

VSAT
Vertical single axis trackers
1.1 Overview

Solar panel or also known as photovoltaic module is one of the most effective way to produce electricity. Extracting useable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of solar cell (a semi conductive material that converts visible light into a direct current). By using solar arrays (a 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.

A solar collector or photovoltaic module receives the maximum solar radiation when the sunrays strike it at right angles. By titling the solar panel to continuously face the sun, we maintain the maximum power output from the panel. This process of sensing and following the position of the sun is known as Solar Tracking. It was resolved that real-time tracking would be necessary to follow the sun effectively, so that no external data would be required in operation. The 2-axis solar panel is very efficient because the sun rise and set in different angle for every season.

1.2 Problem Statement

The sun rise and sets in different angle for every season. Therefore, it is difficult to get the high voltage from the sun light when we used solar energy as our supply. If we used fixed solar panel, it cannot received maximum voltage when solar panel collect the solar radiation and number of solar cells required on a fixed flat panel to get the higher voltage.
1.3 Objective

This project aims to develop a portable dynamic solar tracking system for a solar panel, and provides the maximum voltage from the solar panel. It will be done by using a microcontroller that contains a program that will control the movement of a stepper motor according to the sensor input, and move the solar panel in 2-axis.

1.4 Report Layout

This thesis is organized into five chapters:

Chapter 1

This chapter discusses the overview of solar tracker. It explains about the problem statement and the objective of the project.

Chapter 2

This chapter discusses the literature review. It explains the photovoltaic technology and the overview of the tracker types. It is about the basic knowledge of solar tracker.

Chapter 3

This chapter discusses the methodology involved in designing the project. There are two sections. The section discusses the LDR sensors and the second discusses stepper motors.

Chapter 4

This chapter discusses the result and discussion obtained from testing the project. And the hardware implementation. The result are on the operation of solar tracker.

Chapter 5

Conclusions and recommended future work are presented in this chapter.
CHAPTER TWO

Literature Review

2.1 INTRODUCTION

Energy is the primary and universal measure of all kinds of work by human beings and nature. Primarily, it is the gift of the nature to the humankind in various forms. The consumption of the energy is directly proportional to the progress of the humankind. With ever-growing population, improvement in the living standard of the humanity, industrialization of the developing countries, the global demand for energy increases day by day.

The primary source of energy is fossil fuel, however the finiteness of fossil fuel resources and large scale environmental degradation caused by their widespread use, particularly global warming, urban air pollution and acid rain, strongly suggests that harnessing of non-conventional, renewal and environmental friendly sources of energy.

The green energy also called the regeneration energy, has become need of the hour. Green energy can be recycled, much like solar energy, waterpower, wind power, biomass energy, terrestial heat, etc. [1,2].

One of the most promising renewable energy sources characterized by a huge potential of conversion into electrical power is the solar energy. The conversion of solar radiation into electrical energy by Photo-Voltaic (PV) effect is a very promising technology, being clean, silent and reliable, with very small maintenance costs and small ecological impact.

2.2 Photovoltaic Technology

Photovoltaic are best known as a method for generating power by using solar cells to convert energy from the sun into electricity. The photovoltaic effect refers to photons of light knocking electrons into a higher state of energy to create electricity.

The continuous evolution of the technology determined a sustained increase of the
conversion efficiency of PV panels, but nonetheless the most part of the commercial panels have efficiencies no more than 20%. A constant research preoccupation of the technical community involved in the solar energy harnessing technology refers to various solutions to increase the PV panel's conversion efficiency, among PV efficiency improving solutions we can mention: solar tracking, optimization of solar cells geometry, enhancement of light trapping capability, use of new materials, etc. The output power produced by the PV panels depends strongly on the incident light radiation.

The continuous modification of the sun-earth relative position determines a continuously changing of incident radiation on a fixed PV panel. The point of maximum received energy is reached when the direction of solar radiation is perpendicular on the panel surface. Thus, an increase of the output energy of a given PV panel can be obtained by mounting the panel on a solar tracking device that follows the sun trajectory.

2.3 Solar Panel

Solar panels are devices that convert light into electricity. They are called solar after the sun because the sun is the most powerful source of the light available for use. Solar cells or PV cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charge layers. A solar panel is a collection of solar cells. Although each solar cell provides a relatively small amount of power, many solar cells spread over large area can provide enough power to be useful. To get the most power, solar panels have to be pointed directly at the Sun.

Solar panels are formed out of solar cells that are connected in parallel or series. When connected in series, there is an increase in the overall voltage, connected in parallel increases the overall current. Each individual solar cell is typically made out of crystalline silicon, although other types such as ribbon and thin-film silicon are gaining popularity.

PV cells consist of layered silicon that is doped with different elements to form a p-n junction. The p-type side will contain extra holes or positive charges. The n-type side will contain extra electrons or negative charges. This difference of charge forms a region that is charge neutral and acts as a sort of barrier. When the p-n junction is exposed to light, photons with the correct frequency will form an extra electron/hole pair. However, since the p-n junction creates a potential difference, the electrons cannot jump to the other side only the holes can.
Thus, the electrons must exit through the metal connector and flow through the load, to the connector on the other side of the junction. [3] [4].

Because the PV cells generate a current, cells/panels can be modeled as DC current sources. The amount of current a PV panel produces has a direct correlation with the intensity of light the panel is absorbing. Figure 2.1 is a simple drawing of the system.

![Diagram of Photovoltaic Cell](image)

**Figure 2.1: Angle of Incidence to Solar Cell**

The normal to the cell is perpendicular to the cell’s exposed face. The sunlight comes in and strikes the panel at an angle. The angle of the sunlight to the normal is the angle of incidence ($\theta$). Assuming the sunlight is staying at a constant intensity ($I$), the available sunlight to the solar cell for power generation ($W$) can be calculated as:

$$W = A \cdot I \cdot \cos(\theta)$$

Here, $A$ represents some limiting conversion factor in the design of the panel because they cannot convert 100% of the sunlight absorbed into electrical energy. By this calculation, the maximum power generated will be when the sunlight is hitting the PV cell along its normal and no power will be generated when the sunlight is perpendicular to the normal. With a fixed solar panel, there is significant power lost during the day because the panel is not kept perpendicular to the sun’s rays. A tracking system can keep the angle of incidence within a certain margin and would be able to maximize the power generated.
2.4 Solar Tracker

Solar Tracker is a Device, which follows the movement of the sun as it rotates from the east to the west every day. The main function of all tracking systems is to provide one or two degrees of freedom in movement. Trackers are used to keep solar collectors/solar panels oriented directly towards the sun as it moves through the sky every day. Using solar trackers increases the amount of solar energy, which is received by the solar energy collector and improves the energy output of the heat/electricity, which is generated.

2.4.1 NEED FOR SOLAR TRACKER

The energy contributed by the direct beam drops off with the cosine of the angle between the incoming light and the panel. The table no.2.1 shows the Direct power lost (percentage) due to misalignment (angle $\theta$).

<table>
<thead>
<tr>
<th>Misalignment (angle $\theta$)</th>
<th>Direct power lost (%) = $1 - \cos(\theta)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0^\circ$</td>
<td>0</td>
</tr>
<tr>
<td>$1^\circ$</td>
<td>0.015</td>
</tr>
<tr>
<td>$3^\circ$</td>
<td>0.14</td>
</tr>
<tr>
<td>$8^\circ$</td>
<td>1</td>
</tr>
<tr>
<td>$23.4^\circ$</td>
<td>8.3</td>
</tr>
<tr>
<td>$30^\circ$</td>
<td>13.4</td>
</tr>
<tr>
<td>$45^\circ$</td>
<td>30</td>
</tr>
<tr>
<td>$75^\circ$</td>
<td>&gt;75</td>
</tr>
</tbody>
</table>

The sun travels through 360 degrees east-west a day, but from the perspective of any fixed location the visible portion is 180 degrees during a 1/2 day period. Local horizon effects reduce this somewhat, making the effective motion about 150 degrees. A solar panel in a fixed orientation between the dawn and sunset extremes will see a motion of 75 degrees on either side, and thus, according to the table 2.1, will lose 75% of the energy in the morning and
Literature Review

evening. Rotating the panels to the east and west can help recapture these losses. A tracker rotating in the east-west direction is known as a single-axis tracker.

The sun also moves through 46 degrees north-south over the period of a year. The same set of panels set at the midpoint between the two local extremes will thus see the sun move 23 degrees on either side, causing losses of 8.3%. A tracker that accounts for both the daily and seasonal motions is known as a dual-axis tracker.

2.4.2 TYPES OF SOLAR TRACKERS

1. PASSIVE TRACKING SYSTEMS:

The passive tracking system realizes the movement of the system by utilizing a low boiling point liquid. The added heat of the sun vaporizes this liquid and the center of mass is shifted leading to that the system finds the new equilibrium position as in figure 2.2.

![Passive tracking system](image)

Figure 2.2: Passive tracking system
2. ACTIVE TRACKING SYSTEMS:

The two basic types of active solar tracker are single-axis and double-axis.

2.1 Single axis trackers:

The single axis tracking systems realizes the movement of either elevation or azimuth for a solar power system. Which one of these movements is desired, depends on the technology used on the tracker as well as the space that it is mounted on. For example the parabolic through systems utilize the azimuthally tracking whereas the many rooftop PV-systems utilize elevation tracking because of the lack of space. A single-axis tracker can only pivot in one plane – either horizontally or vertically. This makes it less complicated and generally cheaper than a two-axis tracker, but also less effective at harvesting the total solar energy available at a site. Trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Since the motors consume energy, one wants to use them only as necessary.

Single axis trackers have one degree of freedom that acts as an axis of rotation. There are several common implementations of single axis trackers. These include horizontal single axis trackers (HSAT) and vertical single axis trackers (VSAT).

A horizontal-axis tracker consists of a long horizontal tube to which solar modules are attached. The tube is aligned in a north-south direction, is supported on bearings mounted on pylons or frames, and rotates slowly on its axis to follow the sun's motion across the sky. This kind of tracker is most effective at equatorial latitudes where the sun is overhead at noon. In general, it is effective wherever the solar path is high in the sky for substantial parts of the year, but for this very reason, does not perform well at higher latitudes. For higher latitude, a vertical-axis tracker is better suited. This works well wherever the sun is typically lower in the sky and, at least in the summer months, the days are long.

2.2 Dual Axis Trackers:

Dual axis trackers as shown in the figure 2.3 have two degrees of freedom that act as axes of rotation. Double-axis solar trackers, as the same suggest, can rotate simultaneously in horizontal and vertical directions, and so are able to point exactly at the sun at all times in any location.
Dual axis tracking systems realize movement both along the elevation- and azimuthally axes. These tracking systems naturally provide the best performance, given that the components have high enough accuracy as well.

Figure 2.3 Dual axis solar tracker
3.1 Introduction

This chapter begins with presenting background theory in light sensors and stepper motors as they apply to the dual tracking system. The chapter continues with specific design methodologies pertaining to photocells, stepper motors, microcontroller selection, physical construction, and a software/system operation explanation. In addition, the tracker design and implementation will be presented.

3.2 System Design

The purpose of a solar tracker is to accurately determine the position of the sun. This enables solar panels interfaced to the tracker to obtain the maximum solar radiation. With this particular solar tracker a closed-loop system was made consisting of an electrical system and a mechanical system. The overall block-diagram shown in Figure 3.1.

![Block Diagram of Overall System](image)

**Figure 3.1: Block Diagram of Overall System**

The electrical system consists of four LDR sensors in series with four resistors, these
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placed at the four corners of the solar panel. The intensity of sunlight sensed by the LDR and the output sent to the microcontroller. The microcontroller unit analyzes it and decides the direction in which the panel has to be rotated, with the two stepper motors, which are also part of the mechanical system. The mechanical system also contains tow worm gear assemblies that adjust the LDR sensors.

3.3 Active solar tracking methods

Active tracking is a closed loop method, which uses light sensitive electronics to “see” the sun and position themselves in a very dynamic fashion to the optimal position, figure 3.2 show active tracking flow chart.

![Flow Chart]

Figure 3.2: active tracking flow chart
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3.4 Sensors

A sensor is a device that measures a physical quantity and converts it into a signal, which can be read by an observer or by an instrument.

3.4.1 Light Dependent Resistor

Light Dependent Resistor is made of a high-resistance semiconductor. It can also be referred to as a photoconductor. If light falling on the device is of the high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron conducts electricity, thereby lowering resistance. Hence, Light Dependent Resistors is very useful in light sensor circuits. LDR is very high-resistance, sometimes as high as 10MΩ, when they are illuminated with light resistance drops dramatically.

A Light Dependent Resistor is a resistor that changes in value according to the light falling on it. Connecting the LDR to the microcontroller is very straightforward, but some software “calibrating” is required. It should be remembered that the LDR response is not linear, and so the readings will not change in exactly the same way as with a potentiometer. In general, there is a larger resistance change at brighter light levels. This can be compensated for in the software by using a smaller range at darker light levels. Fig 3.3 shows Light Dependent Resistor.

Figure 3.3: Light Dependent Resistor
3.4.2 Sensors Circuit

We used Four Light Dependent Resistor's as a sensor. They sense the higher density area of sunlight. The solar panel moves to the high light density area through stepper motors.

Each LDR connected to a resistor in series and a power supply forming a potential divider circuit shown in figure 3.4. Thus, any change in light density is proportional to the change in voltage across the LDR's.

![Figure 3.4: potential divider (sensor) circuit](image)

The $R_o$ resistor in the sensor circuit shown in figure 3.4, were selected to equal 10 KΩ. From the potential divider equation, $R_o$ resulted in the following minimum and maximum voltage equation:

Minimum: $5V \times \frac{10KΩ}{(10KΩ + R_{dark}KΩ)}$ .................................................. 3.1

Maximum: $5V \times \frac{10KΩ}{(10KΩ + R_{bright}KΩ)}$ .................................................. 3.2

Were $R_{dark}$ and $R_{bright}$ are the LDR resistor in shade and light.
3.5 MICRO CONTROLLER

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

3.5.1 ATmega32

Atmel ATmega32 is a programmable microcontroller device that is used very frequently in control and embedded system projects. Figure 3.5 show Pin out ATmega32.

![ATmega32 Pinout Diagram]

Figure 3.5: PINOUT ATmega32

The ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed. [5]
3.6 Motor

Motor is used to drive the Solar Tracker to the best angle of exposure of light. We used a stepper motor.

3.6.1 Stepper Motor

The stepper motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied. Many advantages are achieved using this kind of motors, such as higher simplicity, since no brushes or contacts are present, low cost, high reliability, high torque at low speeds, and high accuracy of motion. Many systems with stepper motors need to control the acceleration/deceleration when changing the speed. Figure 3.6 shows a stepper motor.

![Figure 3.6: Stepper Motor](image-url)
3.6.2 BIPOLAR V/S. UNIPOLAR STEPPER MOTORS

The two common types of stepper motors are the bipolar motor and the unipolar motor. Shown in figures 3.7 and 3.8 respectively. The bipolar and unipolar motors are similar, except that the unipolar has a center tap on each winding. The bipolar motor needs current to be driven in both directions through the windings, and a full bridge driver is needed. The center tap on the unipolar motor allows a simpler driving circuit, limiting the current flow to one direction. The main drawback with the unipolar motor is the limited capability to energize all windings at any time, resulting in a lower torque compared to the bipolar motor. The unipolar stepper motor can be used as a bipolar motor by disconnecting the center tap. In unipolar there are 5 wires. One common wire and four wires to which power supply has to be given in a serial order to make it drive. Bipolar can have 6 wires and a pair of wires is given supply at a time to drive it in steps.

Figure 3.7: A 2 phase (winding) bipolar stepper motor

Figure 3.8: A 2 phase (winding) unipolar stepper motor
3.6.3 STEPPER MOTOR CONNECTION DIAGRAM

The wires of the stepper motor shown in Figure 3.9.

![Stepper motor wires diagram]

Figure 3.9. Stepper motor wires.

The connection of stepper motor to a microcontroller shown in figure 3.10.

Example: If we use Microcontroller to give +5v supply to pins a, b, c, d one by one that's:
- a=5v, b=0, c=0, d=0
- a=0, b=5v, c=0, d=0
- a=0, b=0, c=5v, d=0
- a=0, b=0, c=0, d=5v

Then the motor will run.

![Microcontroller and stepper motor connection diagram]

Figure 3.10: Connection of Microcontroller with stepper motor
3.7 Overall Design Simulation

Figure 3.11: Overall design simulation using Proteus ISIS

(Hint: PORT A was configured to be an input port, while PORT C and PORT D were configured as output ports)
3.7.1 Light sensors circuits

Instead of using LDR, four identical variable resistors (R1, R3, R5, R7) were used with a 5 volts DC generator (R1(2)), because there isn't a possibility of using LDR in the simulation with a property of changing light's intensity. Here R1 and R3 represents two opposed sides LDR sensors (East side and West side respectively at initial condition), also R5 and R7 represents the remaining two sensors (North and South side).

From figure 3.12, the two voltage divider which outputs are connected to pin 40 (PA0/ADC0) and pin 39 (PA1/ADC1), they are Analog-to-Digital converting pins, these voltages represents the analog inputs for the East-West axis stepper motor, hence it is converted to 8-bit digital signals.

Here, there are three cases:

Case 1:

R1 value is higher than R3 value: there will be an output in pin 22 (PC0/SCL).
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Case 2:
R3 value is higher than R1 value: there will be an output in pin 23 (PC1/SDA).

Case 3:
R1 value equals R3 value: there will be no output signal.

From figure 3.12, the two voltage divider which outputs are connected to pin 38 (PA2/ADC2) and pin 37 (PA3/ADC3), they are Analog-to-Digital converting pins, these voltages represents the analog inputs for the North-South axis stepper motor, hence it is converted to 8-bit digital signals.

Here, there are three cases:

Case 1:
R5 value is higher than R7 value: there will be an output in pin 14 (PD0/RXD).

Case 2:
R7 value is higher than R5 value: there will be an output in pin 15 (PD1/TXD).

Case 3:
R5 value equals R7 value: there will be no output signal.
3.7.2 Stepper motors circuits

Figure 3.13: Stepper motors circuits

In Figure 3.13, if pin 22 is active, stepper motor 1 (E-W) will rotate clockwise, while it will rotate anticlockwise if pin 23 is active.

In Figure 3.13, if pin 14 is active, stepper motor 2 (N-S) will rotate clockwise, while it will rotate anticlockwise if pin 15 is active.

3.8 Design tools

3.8.1 CodeVision AVR

CodeVision AVR C Compiler is used in this project to compile microcontroller’s codes before using as a reference for Proteus program.

3.8.2 Proteus

For simulation, we used Proteus ISIS 7 professional to test the circuit. Proteus is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. [6]
4.1 Results

The circuit that was connected in the simulation has been worked correctly and gave all the required results in all cases. Each motor had three cases. Here, the result of each motor:

4.1.1 Motor 1 (W-E)

Case one:

Motor 1 (W-E) is in initial position; if R3 (Western sensor) is higher than R1 (Eastern sensor), that means the light intensity affecting R1 is higher than that affecting R3 and this is the first motivation of the day. In the morning motor 1 (W-E) start to rotate clockwise (from West to East), until the two sensors are having the same value (R1=R3) as shown in figure 4.1.

![Figure 4.1: Motor 1 (W-E) movement when (R3>R1)](image)

Case two:

After case one if (R1=R3) the sensor measured the same value. The motor will not rotate, that means the solar cell is now in the correct position facing the sun.
Results and Discussion

Case three:

After case two, motor 1 will stop rotating, and the sun continues moving towards West the Eastern sensor (R1) begins to have higher value than Western sensor (R3); so motor 1 (W-E) will rotate anticlockwise until two sensors read the same value (R1=R3) as shown in figure 4.2.

![Figure 4.2: Motor 1 (W-E) movement when (R3=R1)](image)

4.1.2 Motor 2 (N-S)

During the year the sun coordinates in the North-South axis is changing almost continuously (from north to south and vice versa). Here we have three cases:

Case one:

The Northern sensor (R5) is higher than the Southern sensor (R7). Here motor 2 (N-S) starts to rotate clockwise, so the value of R7 increases until the two sensors are having the same value (R5=R7) as shown in figure 4.3.
Results and Discussion

Case 2:

The Southern sensor (R7) is higher than the Northern sensor (R5). Here motor 2 (N-S) starts to rotate anticlockwise, so the value of R5 increases until the two sensors are having the same value (R5=R7) as shown in figure 4.4.

Case 3:

This case happens when the two sensors read the same value (R5=R7). The motor will not rotate, that means the solar cell is now in the correct position facing the sun.
4.2 Hardware Implementation

We tried to implement the simulation circuit, the microcontroller ATmega32 worked correctly when we program it with PROGRAM DUMPER shown in figure 4.5. The stepper motor did not work correctly due to unsuccessful wiring. The hardware implementation shown in figure 4.6.

Figure 4.5: PROGRAM DUMPER

Figure 4.6: hardware implementation
Results and Discussion

4.3 Discussion

The simulation of the 2-axis tracker was designed successfully, and met its design goals. The design was tested in Proteus and all possible cases were done correctly, to give the correct position for the solar cell.

The hardware model was implemented successfully; the mechanical design was designed to move the solar panel model in four directions North, South, East and West.
CHAPTER FIVIE
CONCLUSION AND FUTURE WORK

5.1 Conclusion

This thesis has presented a means of controlling a sun-tracking array with an embedded microcontroller system. Specifically, it demonstrates a working software solution for maximizing solar cell output by positioning a solar array at the point of maximum light intensity. This project presents a method of searching and tracking for the sun.

5.1 Future work

The project needs further work before practical usage. This work could be summarized as follows:

- In the mechanical system, we must ensure that the movement of the motor and worm gears guarantee that the solar panel facing the sun.
- Increase the sensitivity and accuracy of tracking by using a phototransistor with an amplification circuit, this would provide improved resolution and better tracking accuracy.
References


[5] ATmega32/L Datasheet at:

[6] Proteus (design software). Article at:
http://en.wikipedia.org/wiki/proteus_(design_software)
Appendix

APPENDIX

Software

This appendix is about the code of the ATmega32 microcontroller.

***********************************************************************

Project: 2-Axis Solar tracker
Version:
Date : 7/9/2013
Author: Freeware, for evaluation and non-commercial use only
Company:
Comments:
Chip type : ATmega32
Program type : Application
AVR Core Clock frequency: 1.000000 MHz
Memory model : Small
External RAM size : 0
Data Stack size : 512
***********************************************************************

#include <mega32.h>

#include <delay.h>
int a,b,c,d ;

#define ADC_VREF_TYPE 0x60

// Read the 8 most significant bits
// of the AD conversion result
Appendix

unsigned char read_adc(unsigned char adc_input)
{
    ADMUX = adc_input | (ADC_VREF_TYPE & 0xff);
    // Delay needed for the stabilization of the ADC input voltage
    delay_us(10);
    // Start the AD conversion
    ADCSRA = 0x40;
    // Wait for the AD conversion to complete
    while (((ADCSRA & 0x10) == 0);
    ADCSRA = 0x10;
    return ADCH;
}

// Declare your global variables here

void main(void)
{
    // Declare your local variables here

    // Input/Output Ports initialization
    // Port A initialization
    // Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In Func0=In
    // State7=T State6=T State5=T State4=T State3=T State2=T State1=T State0=T
    PORTA = 0x00;
    DDRA = 0x00;

    // Port B initialization
Appendix

// Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In Func0=In
// State7=T State6=T State5=T State4=T State3=T State2=T State1=T State0=T
PORTB=0x00;
DDRB=0x00;

// Port C initialization
// Func7=Out Func6=Out Func5=Out Func4=Out Func3=Out Func2=Out Func1=Out Func0=Out
// State7=0 State6=0 State5=0 State4=0 State3=0 State2=0 State1=0 State0=0
PORTC=0x00;
DDRC=0xFF;

// Port D initialization
// Func7=Out Func6=Out Func5=Out Func4=Out Func3=Out Func2=Out Func1=Out Func0=Out
// State7=0 State6=0 State5=0 State4=0 State3=0 State2=0 State1=0 State0=0
PORTD=0x00;
DDRD=0xFF;

// Timer/Counter 0 initialization
// Clock source: System Clock
// Clock value: Timer 0 Stopped
// Mode: Normal top=0xFF
// OC0 output: Disconnected
TCCR0=0x00;
TCNT0=0x00;
OCR0=0x00;
Appendix

// Timer/Counter 1 initialization
// Clock source: System Clock
// Clock value: Timer1 Stopped
// Mode: Normal top=0xFFFF
// OC1A output: Discon.
// OC1B output: Discon.
// Noise Canceler: Off
// Input Capture on Falling Edge
// Timer1 Overflow Interrupt: Off
// Input Capture Interrupt: Off
// Compare A Match Interrupt: Off
// Compare B Match Interrupt: Off
TCCR1A=0x00;
TCCR1B=0x00;
TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;

// Timer/Counter 2 initialization
// Clock source: System Clock
// Clock value: Timer2 Stopped
Appendix

// Mode: Normal top=0xFF
// OC2 output: Disconnected
ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;

// External Interrupt(s) initialization
// INT0: Off
// INT1: Off
// INT2: Off
MCUCR=0x00;
MCUCSR=0x00;

// Timer(s)/Counter(s) Interrupt(s) initialization
TIMSK=0x00;

// Analog Comparator initialization
// Analog Comparator: Off
// Analog Comparator Input Capture by Timer/Counter 1: Off
ACSR=0x80;
SFIOR=0x00;

// ADC initialization
// ADC Clock frequency: 500.000 kHz
// ADC Voltage Reference: AVCC pin
// Only the 8 most significant bits of
Appendix

// the AD conversion result are used
ADMUX=ADC_VREF_TYPE & 0xff;
ADCSRA=0x81;

while (1)
{
    // Place your code here

char asc[10];
a=read_adc(0);
//a= a*5/256;
b =read_adc(1);
//b= b*5/256;}
c=read_adc(2);
//c=c*5/256);
d=read_adc(3);
//d=d*5/256);

if (a>b)
{
    PORTC=0x0C;
delay_ms(500);
    PORTC=0x09;
delay_ms(500);
    PORTC=0x03;
delay_ms(500);
    PORTC=0x06;
delay_ms(500);
}

if (a<b)
{
    PORTC=0x06;
delay_ms(500);
    PORTC=0x03;
delay_ms(500);
    PORTC=0x09;
delay_ms(500);
    PORTC=0x0C;
delay_ms(500);
}

if (a==!2.1157 & & a==b)
{
    PORTC=0x00;
}

if (a<2.1157 & & a==b)
{
    delay_ms(500);
    PORTC=0x00;
}


if (c>d)
{
}
Appendix

PORTD=0x0C;
delay_ms(500);
PORTD=0x09;

delay_ms(500);
PORTD=0x03;

delay_ms(500);
PORTD=0x06;

delay_ms(500);
}
if(c<d)
{
PORTD=0x06;
delay_ms(500);
PORTD=0x03;

delay_ms(500);
PORTD=0x09;
delay_ms(500);
PORTD=0x0c;
delay_ms(500);
}
if (c==d)
{
PORTD=0x00;
} }