SOLAR PANEL TRACKING SYSTEM

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INDEX NO.124011

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A REPORT SUBMITTED TO

University Of Khartoum

In partial fulfillment for the degree of

B.Sc. (HONS) Electrical and Electronics Engineering

(INSTRUMENTATION AND CONTROL ENGINEERING)

Faculty of Engineering

Department of Electrical and Electronic Engineering

October 2017
DECLARATION OF ORIGINALITY

I declare this report entitled “Solar Panel Tracking System” is my own work except as cited in references. The report has been not accepted for any degree and it is not being submitted currently in candidature for any degree or other reward.

Signature: ____________________

Name: _______________________

Date: ________________________
ACKNOWLEDGEMENT

First and foremost, I am very grateful to the almighty ALLAH S.W.T for giving me the key and opportunity to accomplish my Final Year Project.

In particular I wish to express my sincere appreciations to my supervisor Prof. Sami Mohammed Sharif for his dedication, encouragement and guidance through this project.

Secondly I wish to thank all my teachers, colleges especially my partner in this project AHMED ADEL MOHAMMED ALHASSAN SHARFI for their corporation directly or indirectly in this project.
DEDICATION

To my parents

To my brother MOHAMMED OSMAN MOHHAMED KOKO for all the encouragement and cheering through this hard long journey.

To all my friends.
ABSTRACT

With the shortage of fossil fuels in the world, the need for alternative means of energy production has increased. Solar energy is one of the most important types of alternative energies that can be used in many fields such as the generation of electricity, heating and cooking.

Solar systems usually consist of solar panels or heat concentrators. In order to increase the efficiency of the system, the solar panel or concentrators must be directed directly to the sun.

In this project, a solar cooker and its electrical control system were designed and constructed using an open loop control system via ATMEGA and DC motor. The motion of the electric motor is transferred to the dish via rollers and a shaft.

As a result, a system has been obtained with a fixed focal point that can be used for cooking.
المستخلص

مع نقص كمية الوقود الأحفوري في العالم ازدادت الحاجة لإيجاد مسيلة بديلة لإنتاج الطاقة. تعتبر الطاقة الشمسية من أهم أنواع الطاقات البديلة التي يمكن استخدامها في مجالات عديدة كإنتاج الكهرباء والتدفئة والطبخ. عادة ما تتكون أنظمة الطاقة الشمسية من الواح شمسية أو أطباق لتجميع الطاقة الشمسية. ومن أجل زيادة كفاءة استخدام الطاقة يجب أن يكون اللوح الشمسي أو الطبق موجهًا للشمس بصورة مباشرة.

في هذا المشروع تم تصميم وبناء جهاز طبخ شمسي ونظام التحكم الكهربائي الخاص به باستخدام نظام الحلقة المفتوحة عن طريق اتمام ومحرك يعمل على التيار المباشر يتم نقل الحركة من المحرك الكهربائي إلى الطبق عن طريق بكرات وعمود إداره.

نتيجة لذلك تم الحصول على نظام بنقطة تركيز ثابتة يمكن استخراها للطبخ.
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<tr>
<td>A</td>
<td>Ampere</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ALU</td>
<td>Athematic Logic Unit</td>
</tr>
<tr>
<td>AVR</td>
<td>Advance Virtual RISC</td>
</tr>
<tr>
<td>cm</td>
<td>Centimeter</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>I</td>
<td>Current</td>
</tr>
<tr>
<td>IC</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/output</td>
</tr>
<tr>
<td>MH</td>
<td>Mega Hertz</td>
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<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaic</td>
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<tr>
<td>PWM</td>
<td>Pulse Width Modulation</td>
</tr>
<tr>
<td>V</td>
<td>Voltage</td>
</tr>
<tr>
<td>Vin</td>
<td>Input Voltage</td>
</tr>
<tr>
<td>Vout</td>
<td>Output Voltage</td>
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<tr>
<td>Φ</td>
<td>Solar Altitude</td>
</tr>
<tr>
<td>Α</td>
<td>Solar Azimuth</td>
</tr>
<tr>
<td>Θ</td>
<td>Angle of Incidence</td>
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<tr>
<td>Δ</td>
<td>The Sun declination Angle</td>
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<tr>
<td>Vs</td>
<td>Source Voltage</td>
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<tr>
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<td>Angular Velocity of the motor</td>
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<tr>
<td>Ki</td>
<td>Electrical constant</td>
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<tr>
<td>τ</td>
<td>Torque</td>
</tr>
<tr>
<td>Kt</td>
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CHAPTER 1: INTRODUCTION

1.1. Overview

Today, many countries use electricity to heat their homes, power vehicles, light buildings and use electronic devices. This electricity comes from energy sources such as the burning of petroleum and other fossil fuels. Countries require a massive amount of fuel to generate enough electricity to meet demands. Most of it comes from the burning of fossil fuels. Unfortunately, there is a limited amount of fossil fuels on the Earth.

The need for these fuels has grown so great that sometime in the near future it is likely that there will no longer be any of these fossil fuels remaining. In addition, the burning of fossil fuels damages the environment by releasing harmful gases and substances into the air.

This has been an issue ever since coal and oil were first used for heating and cooking around 200 BC. Solar energy is clean and is abundantly available. Solar technologies use the sun to provide heat, light, electricity, etc. for domestic and industrial applications. With the alarming rate of depletion of the major conventional energy resources such as Coal, Petroleum and Natural gas, coupled with the environmental degradation caused by the process of harnessing these energy sources, it has become an urgent necessity to invest in renewable energy resources that would power the future sufficiently without degrading the environment through greenhouse emission.

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 microcontroller.
1.2. Problem statement

The sun moves from east to west. Solar panels are designed to remain fixed thus the power collecting from it the less. A solar tracking system is designed to adjust the direction of the solar panel accordingly with the movement of the sun.

1.3. Objectives

The main objective of this project is to implement and design a solar tracking system based on ATmega32 and a DC motor.

1.4. Thesis layout

This thesis consist of five chapters. This chapter contains a brief over view on the project, problem statement and the thesis layout.

Chapter 2 contains an introduction to solar tracking systems, solar geometry, and the different types of solar trackers, the parabolic dish and its main principles of operation. And the major project component.

Chapter 3 includes the project methodology, it contains a brief overview on the methodology used, it explains the tracking algorithm to be used, and the methodology used in designing and implementing the system.

Chapter 4 discusses the results obtained from the project it’s important to determine whether the project objectives are achieved or not.

Chapter 5 concludes the whole project and give recommendations to be made on the project in the future in order to improve the project.
CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Human beings are faced with oil and coal depletion of fossil fuels such as a serious threat that these fossil fuels is a one-time non-renewable resources, limited reserves and a large amount of combustion of carbon dioxide, causing the Earth’s warming, deterioration of the ecological environment. With the development of society energy saving and environmental protection has become a topical issue. The green energy also called the regeneration energy, has gained much attention nowadays. Green energy can be recycled, much like solar energy, water power, wind power, biomass energy, terrestrial heat, temperature difference of sea, sea waves, morning and evening tides, etc.[1]

Among these, solar energy is the most powerful resource that can be used to generate power. A good energy source prospect for industrial continuous processes needs to be:

• More or less constant energy throughout the year
  • Highly reliable and needs little maintenance.
  • Low cost to build and operate.
  • Virtually no environmental impact.
  • Modular and thus flexible in terms of size and applications.
  • Landscape friendly.

2.2 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 scientist throughthe19th 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. 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.[1]

Over the last few decades, researchers around the world have been working tirelessly to come up with more innovative and efficient ways to harness solar power. Photovoltaic (PV), solar concentrators and solar reflectors are used to harness the sun energy.

2.3 Solar geometry

When designing a system that depends on the position of the sun it is important to take into consideration the seasonal and hourly changes in the position of the sun. The position of the sun is determined by two angles—the first angle is solar altitude or elevation (denoted by $\phi$) describing the sun’s position from the horizontal. The second
The angle of incidence is not a measure of the sun's position, but rather a measure of the amount of radiation incident on a vertical surface. The angle of incidence is related to the solar altitude as follows:

$$\theta = 90^\circ - \phi$$

Together, the two angles provide useful information about the orientation of incoming sunlight on an object or structure. Knowing this, solar collectors and other devices should be installed so they are within 20° of either side of perpendicular to the sun.

By incorporating a system that adjusts to the incident angle of the sun, we can further control the angle incident on the surface of the collector.

The earth rotates around its celestial poles in 24 hours causing the succession of day and night, this rotation is perpendicular to the equator but it is not perpendicular to the plane of the earth orbit. In fact the earth daily rotation tilts with angle from +23.4 to -23.4. This results in a 47° peak solar altitude angle difference, causing the hemisphere-specific difference between summer and winter.

On the day of the summer solstice, the sun is above the horizon for the longest period of time in the northern hemisphere. Hence, it is the longest day for daylight there.
Conversely, the Sun remains below the horizon at all points within the Antarctic Circle on this day. On the day of the winter solstice, the smallest portion of the northern hemisphere is exposed to the Sun and the Sun is above the horizon for the shortest period of time there.

In general, the Sun declination angle, $\delta$, is defined to be that angle made between a ray of the Sun, when extended to the center of the earth and the equatorial plane. The Sun declination angle ($\delta$) has the range: $-23.5^\circ < \delta < +23.5^\circ$ during its yearly cycle.

Solar noon is defined to be that time of day at which the Sun’s rays are directed perpendicular to a given line of longitude. Thus, solar noon occurs at the same instant for all locations along any common line of longitude. Solar Noon will occur one hour earlier for every 15 degrees of longitude to the east of a given line and one hour later for every 15 degrees west. (This is because it takes the Earth 24 hours to rotate 360°.)

2.4 Solar trackers

A solar tracker is basically a device or system that coupled to a parabolic dish through gears or any other mechanical mechanism to rotate the dish so it can track the relative motion of the sun across the sky to achieve the maximum thermal energy, so solar trackers must be angled correctly to collect energy. All concentrated solar systems have trackers because the systems do not produce energy unless directed correctly toward the sun.
2.5 Types of solar trackers

Single-axis solar trackers rotate on one axis moving back and forth in a single direction. Different types of single-axis trackers include horizontal, vertical, tilted, and polar aligned, which rotate as the names imply. Dual-axis trackers continually face the sun because they can move in two different directions. Types include tip-tilt and azimuth-altitude.

Dual-axis tracking is typically used to orient a mirror and redirect sunlight along a fixed axis towards a stationary receiver. Because these trackers follow the sun vertically and horizontally they help obtain maximum solar energy generation.

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.

Active 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.

The required accuracy of the solar tracker depends on the application. Concentrators, especially in solar cell applications, require 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 ground-mounted 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 photovoltaic, 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 ray. An open-loop type of controller computes its input into a system using only the current state and the algorithm of the system and without using feedback to determine if its input has achieved the desired goal (i.e. algorithm-based). The system is simple and cheap. It does not observe the output of the processes that it is controlling. Consequently, an open-loop system cannot correct any errors so that it could make and may not compensate for disturbances in the system. Open-loop control algorithms of sun tracking systems utilize some form of solar irradiation geometry model .[3]

Closed-loop types of sun tracking systems are based on feedback control principles. In these systems, a number of inputs are transferred to a controller from sensors which detect relevant parameters induced by the sun, manipulated in the controller and then yield outputs (i.e. sensor-based). The system is more complicated and more expensive than the closed-loop type of solar tracker system . The system will correct any errors or disturbances that could occur to the system in order to achieve the desired output.

**2.6 Parabolic dish**

The parabola is a special type of curves that has a focal point to which parallel beams of light will be reflected. The opposite is also true. A light source placed at the focus point will create a parallel beam of light, as in a spotlight. A parabolic is the shape of the path of a projectile fired into the air and allowed to fall again (assuming no friction from the air), or a stone that is thrown into the air. It is also the shape obtained if you were to cut a cone shape along a line parallel to its side.

The shape is not part of a circle or an ellipse, and all parabolas are the same shape, they only differ in their size and the portion of the shape that you use. In other words you do not get pointed parabolas and blunt or flat ones. A parabola that appears to be just a shallow dish, is the same shape as the very top part of the path traced by a stone thrown in the air.
2.7 Scheffler cooker

A Scheffler cooker (named after its inventor, Wolfgang Scheffler) uses a large ideally parabolic reflector which is rotated around an axis that is parallel with the earth's using a mechanical mechanism, turning at 15 degrees per hour to compensate for the earth's rotation. The axis passes through the reflector's center of mass, allowing the reflector to be turned easily.

The cooking vessel is located at the focus which is on the axis of rotation, so the mirror concentrates sunlight onto it all day.

The mirror has to be occasionally tilted about a perpendicular axis to compensate for the seasonal variation in the sun's declination.

This perpendicular axis does not pass through the cooking vessel. Therefore, if the reflector were a rigid parabolic, its focus would not remain stationary at the cooking vessel as the reflector tilts.

To keep the focus stationary, the reflector's shape has to vary. It remains parabolic, but its focal length and other parameters change as it tilts. The Scheffler reflector is therefore flexible, and can be bent to adjust its shape.

It is often made up of a large number of small plane sections, such as glass mirrors, joined together by flexible plastic. A framework that supports the reflector includes a mechanism that can be used to tilt it and also bend it appropriately. The mirror is never exactly parabolic, but it is always close enough for cooking purposes.
2.8 ATMEGA 32

A microcontroller is a small computer on a single chip (integrated circuit), it is similar to system on chips it contains one or more processor cores along with a memory and programmable I/O peripherals. Microcontrollers are designed for embedded applications in contrast to the microprocessors used in computer it used in automatically controlled devices. 8-bit RISC microcontrollers, one of the first microcontrollers to use on-chip flash memory for program storage. ATMEGA is a low power CMOS 8-bit microcontroller based on the AVR enhanced RISC (Reduced Instruction Set Computing) architecture, it is a member of AVR series devices family developed by Atmel in 1996.

AVR microcontrollers have a special advantages over the other common devices, they can execute 1 million per second instructions if the frequency cycle is 1MH, and they are modified Harvard architectures.

ATMEGA32 has 32 8-bit registers which are directly connected to the arithmetic logic unit (ALU), the ATMEGA32 has many features such as 32 digital I/O pins (4ports/8pins), three built in timers and counters divided into two 8-bit timers known as timer0 and timer2, and a 16-bit timer known as timer1, the ATMEGA32 has inbuilt IC chip that converts analog signal into digital, the conversion can be done to 10 or 8 bit digital output, an external reference can be used or the 2.56V internal reference, the external reference can be connected to the AREF pin. The ATMEGA32 has three data transfer module the two wire interface, USART and the serial peripheral interface which are all embedded on it.
ATMEGA 32 has a 32Kbytes of In-System Self-programmable Flash program memory, 1024 Bytes EEPROM, 2Kbytes Internal SRAM. Write/Erase Cycles: 10,000 Flash/ 100,000 EEPROM. The ATMEGA32 clock can run on a frequency from 1 to 16 MH.

2.9 Electric Motors

2.9.1 Introduction:

The motor or an electrical motor is a device that has brought about one of the biggest advancements in the fields of engineering and technology ever since the invention of electricity. A motor is an electro-mechanical device that converts electrical energy to mechanical energy. Without motor we had still been living in Sir Thomas Edison’s Era where the only purpose of electricity would have been to glow bulbs. There are different types of motor have been developed for different specific purposes.

In simple words a device that produces rotational force is a motor. The very basic principal of functioning of an electrical motor lies on the fact that force is experienced in the direction perpendicular to magnetic field and the current, when field and electric current are made to interact with each other. Ever since the invention of motors, a lot of advancements have taken place in this field of engineering and it has become a subject of extreme importance for modern engineers.

2.9.2 Types of Electric Motor:

The primary classification of motor or types of motor can be described as shown in figure 2.6.
2.9.3 DC Motor

DC motors consist of rotor-mounted windings (armature) and stationary windings (field poles). In all DC motors, except permanent magnet motors, current must be conducted to the armature windings by passing current through carbon brushes that slide over a set of copper surfaces called a commutator, which is mounted on the rotor.

The commutator bars are soldered to armature coils. The brush/commutator combination makes a sliding switch that energizes particular portions of the armature, based on the position of the rotor. This process creates north and south magnetic poles on the rotor that are attracted to or repelled by north and south poles on the stator, which are formed by passing direct current through the field windings. It's this magnetic attraction and repulsion that causes the rotor to rotate.[4]
The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage and/or the field current will change the rotor speed. The main problem with DC motors is that the brushes/commutator combination requires periodic maintenance.

The types of DC motors differ in the field:

2.9.3.1 Permanent magnet

The field of a permanent magnet motor is supplied from a permanent magnet it has an excellent starting torque with a good speed regulation, the disadvantages of this type is that they are limited to the load they can derive.

![Permanent Magnet Diagram](image1)

Figure 2.8 Permanent magnet

The field of a permanent magnet motor is supplied from a permanent magnet it has an excellent starting torque with a good speed regulation, the disadvantages of this type is that they are limited to the load they can derive.

2.9.3.2 Series motor

![Series Motor Diagram](image2)

Figure 2.9 Series motor
In this type the field is connected in parallel with the armature, it does offer a good speed regulation and simplified speed control for reversing, the field can be exited separately or with the same source as the armature.

2.9.3.3 Compound motor

![Compound motor diagram]

This type has a field and armature connected in series and separately exited shunt field, the series shunt combination in order to provide a better starting torque and better speed regulation since the series provides the torque and the shunt provides the speed regulation.

2.10 Motor drives

A drive is the electronic device that harnesses and controls the electrical energy sent to the motor. The drive feeds electricity into the motor in varying amounts and at varying frequencies, thereby indirectly controlling the motor’s speed and torque. There are two types of drives: a standard inverter drive for controlling speed and torque only; and a servo drive for controlling speed and torque, as well as positioning machine components used in applications that require complex motion.

Since the motor required a relatively high current and voltage to rotate and most microcontrollers operates at low voltage and requires low current thus the micro controller cannot supply the motor with the required voltage and current hence the motor driver is needed beside the control of the rotation direction.

The most common used motor drive is the L293 family such as L293d and L293NE, these motor drives are designed to control two DC motors at the same time.

L239D is a two H-Bridge which is the simplest circuit for a low current rated motor. The L293D has 16 pins explained as follow:

- 4 input pins
- 4 output pins
- 4 ground pins
- 2 voltage pins
- 2 enable pins

The pins configuration is shown on figure:

![L293D pins configurations](image)

The L293D IC receives signals from the microprocessor and transmits the relative signal to the motors. It has two voltage pins, one of which is used to draw current for the working of the L293D and the other is used to apply voltage to the motors. The L293D switches it output signal according to the input received from the microprocessor.

Table 1 L293D Pin characteristics

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Enable 1-2, when this is HIGH the left part of the IC will work and when it is low the left part won’t work. So, this is the Master Control pin for the left part of IC</td>
</tr>
<tr>
<td>2</td>
<td>INPUT 1, when this pin is HIGH the current will flow though output 1</td>
</tr>
<tr>
<td>3</td>
<td>OUTPUT 1, this pin should be connected to one of the terminal of motor</td>
</tr>
<tr>
<td>4,5</td>
<td>GND, ground pins</td>
</tr>
<tr>
<td>6</td>
<td>OUTPUT 2, this pin should be connected to one of the terminal of motor</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>INPUT 2, when this pin is HIGH the current will flow though output 2</td>
</tr>
<tr>
<td>8</td>
<td>VC, this is the voltage which will be supplied to the motor. So, if you are driving 12 V DC motors then make sure that this pin is supplied with 12 V</td>
</tr>
<tr>
<td>16</td>
<td>VSS, this is the power source to the IC. So, this pin should be supplied with 5 V</td>
</tr>
<tr>
<td>15</td>
<td>INPUT 4, when this pin is HIGH the current will flow though output 4</td>
</tr>
<tr>
<td>14</td>
<td>OUTPUT 4, this pin should be connected to one of the terminal of motor</td>
</tr>
<tr>
<td>13,12</td>
<td>GND, ground pins</td>
</tr>
<tr>
<td>11</td>
<td>OUTPUT 3, this pin should be connected to one of the terminal of motor</td>
</tr>
<tr>
<td>10</td>
<td>INPUT 3, when this pin is HIGH the current will flow though output 3</td>
</tr>
<tr>
<td>9</td>
<td>Enable 3-4, when this is HIGH the right part of the IC will work and when it is low the right part won’t work. So, this is the Master Control pin for the right part of IC</td>
</tr>
</tbody>
</table>

2.11 Photovoltaic

Photovoltaic converts sun light into direct current, the name photovoltaic comes from the fact that it converts the light (photo) to electricity (voltages).

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.

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.[5]
2.12 Pulleys

A pulley is a wheel (usually with a grooved rim) which is used to transfer force or speed or to turn another wheel. Pulleys connected in pairs by a looped belt can be used in a similar fashion to gears.

A rope connected to a load can be pass through one or more pulleys to move the load from the other end. Using a single pulley changes the direction of the force. Using multiple pulleys makes it easier to move the load (in addition to possibly changing the direction). This happens because more rope must be pulled in order to move the load the same distance. The more pulleys used, the easier it is to move, but the more rope that must be pulled to move the load the same distance.\[6\]

![Figure 2.13 Photovoltaic](image1.png)

**Figure 2.13 Photovoltaic**

**Figure 2.14 Two pulleys connected by an uncrossed belt turn in the same direction.**

When two pulleys of the same size are connected by a belt, they turn at the same speed.
When two pulleys of different size are connected by a belt, the smaller one turns faster and the larger one turns slower.

2.13 Voltage Regulator

A voltage regulator generates a fixed output voltage of a preset magnitude that remains constant regardless of changes to its input voltage or load conditions.

There are two types of voltage regulators:

- Linear
- Switching

A linear regulator employs an active (BJT or MOSFET) pass device (series or shunt) controlled by a high gain differential amplifier. It compares the output voltage with a precise reference voltage and adjusts the pass device to maintain a constant output voltage.

A switching regulator converts the dc input voltage to a switched voltage applied to a power MOSFET or BJT switch. The filtered power switch output voltage is fed back to a circuit that controls the power switch on and off times so that the output voltage remains constant regardless of input voltage or load current changes.

There are three common switching regulator topologies:

- Buck (step-down):

![Buck voltage regulator](image)

Figure 2.15 Buck voltage regulator

- Boost (step-up):
Buck-boost (step-up/step-down):

Other topologies include the fly-back, SEPIC, Cuk, push-pull, forward, full-bridge, and half-bridge topologies.

Higher switching frequencies mean the voltage regulator can use smaller inductors and capacitors. It also means higher switching losses and greater noise in the circuit.

Losses occur as a result of the power needed to turn the MOSFET on and off, which are associated with the MOSFET’s gate driver. Also, MOSFET power losses occur because it takes a finite time to switch to/from the conduction to non-conduction
states. Losses are also due to the energy needed to charge and discharge the capacitance of the MOSFET gate between the threshold voltage and gate voltage.

The linear regulator’s power dissipation is directly proportional to its output current for a given input and output voltage, so typical efficiencies can be 50% or even lower. Using the optimum components, a switching regulator can achieve efficiencies in the 90% range. However, the noise output from a linear regulator is much lower than a switching regulator with the same output voltage and current requirements. Typically, the switching regulator can drive higher current loads than a linear regulator.

Switching regulators require a means to vary their output voltage in response to input and output voltage changes. One approach is to use PWM that controls the input to the associated power switch, which controls it’s on and off time (duty cycle). In operation, the regulator’s filtered output voltage is fed back to the PWM controller to control the duty cycle. If the filtered output tends to change, the feedback applied to the PWM controller varies the duty cycle to maintain a constant output voltage.

Among the basic parameters are input voltage, output voltage, and output current. Depending on the application, other parameters may be important, such as output ripple voltage, load transient response, output noise, and efficiency. Important parameters for the linear regulator are dropout voltage, PSRR (power supply rejection ratio), and output noise.[7]

2.13.1 LM7805

7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value.

The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.
Figure 2.18 LM7805

Table 2 LM7805 Pin description

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Function</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Input voltage (5V-18V)</td>
<td>Input</td>
</tr>
<tr>
<td>2</td>
<td>Ground (0V)</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>Regulated output; 5V (4.8V-5.2V)</td>
<td>Output</td>
</tr>
</tbody>
</table>
CHAPTER 3: METHODOLOGY

3.1 Overview

Solar panel tracking system can be divided into two sections:

- Hardware section.
- Software section.

The software section is used to direct the hardware section into the optimum point. The methodology of this solar panel tracking system can be summarized as follow:

First the satellite parabolic dish is derived into the right point where it’s facing the sun perpendicularly in order to reflect the sun rays into the focal point where a cooker is placed.

After the system powers up the microcontroller will start its timer and count up for twenty minutes and then it will drive the motor to the west direction. The movement of the motor will be transferred to the parabolic dish through two pulleys connected with a built, the larger pulley is connected to a shaft which is connected to the parabolic dish.
3.2 **Hardware design**

Hardware design is divided into two sections:

**3.2.1 Mechanical design**

A normal 130cm*120cm satellite dish was covered with a stainless steel in order to make it reflecting for the sun rays, the stainless steel is known for being a perfect reflection material so it was chosen, it was cut into three pieces and riveted to the dish.
The parabolic dish was attached to a metal base, the metal base provides support to the parabolic dish, and it was constructed in a special design to hold the parabolic dish against the wind in the windy days as shown in the figure 3.3.

![Figure 3.3 Metal base](image)

The parabolic dish is linked to its elevation bracket to provide elevation adjustment to the dish when the sun's seasonal position changes.
This elevation bracket is connected to a 40cm steel shaft through a 4 inches screw, and the screw is welded to the shaft.

A shaft is a rotating element, usually circular in cross section, which is used in power transmission from one part to another, or from a machine which generate power to a machine which absorbs power. The various members such as gears and pulleys are mounted on it.
The other side of the shaft is linked to an 8 inches pulley, a 3 inches pulley is linked with the motor shaft and the two pulleys are belted together as shown on the figure 3.6.

![Figure 3.6 The pulleys system](image)

### 3.2.2 Electrical Design

The electrical system consist of the following:

- ATMEGA32.
- L293D motor driver.
- 24V DC motor.
- LM7805 voltage regulator.
- Photovoltaic panels.
The photovoltaic panels are used to supply power to the system. The voltage driven from the photovoltaic panel is regulated through the LM78505 voltage regulator.

### 3.2.2.1 LM7805

The LM7805 voltage regulator receives a variable voltage at its input pin from the photovoltaic panels and provides a constant 5 voltage at its output pin and dissipate the difference as heat. The regulated voltage is used to supply the ATMEGA32 VVC pin.

### 3.2.2.2 ATMEGA32

The ATMEGA32 initializes its timer and starts counting up till it reaches twenty minutes then it will set pin zero of portA high, this signal is used as input for the L239D motor drive which drives the motor 5 degrees to the west with a constant speed, then the ATMEGA32 resets the timer and starts counting up again.
3.2.2.3 L293D

As explained in chapter 1, the L293D is a motor drive used to drive the motor to the west direction with a constant speed. Pin 2 and 7 in the L293D are the input pins connected to pin 0 and 1 in PORTA of the ATMEGA32. Pin 1 is the enable pin and it was set to high to select the side of the chip which is connected to the motor since the L293D can operate two motors at the same time. The VS pin is connected to the 24 voltage source to deliver the desired input voltage to the motor since the ATMEGA32 cannot deliver more than 5 volts at its output pins. Pin 3 and 6 are the output pins, which were connected to the motor as shown in the figure 3.9.

![L293D Circuit Diagram](image)

Figure 3.9 L293D

3.2.2.4 DC MOTOR

A 24V SPAL DC motor is used to drive the parabolic dish to the optimum point. The motor originally was a dc fan used in heavy vehicle.
The motor was dismantled from its fins as shown in figure 3.11:
The motor is rated at nominal 24V voltage but it has a wide range of voltage (from 5V to 43V), the 24V corresponds to the highest efficiency. If a motor is operated outside of its nominal voltage the efficiency of the motor goes down and often an additional current is required or generating more heat and reduce the lifespan of the motor.

The motor speed is proportional to the input voltage this means that the more input voltage the more speed but as mentioned previously operating a motor outside its nominal voltage causes the efficiency to go down.

\[ V_s = IR \times Ki \omega \]  

*Equation 2 voltage speed relation*

Thus a gear ratio is needed to reduce the speed of the motor.

![Figure 3.12 The pulleys system connected to the motor](image)
The rated current of the motor is 10.7A this means that it does consume a huge amount of energy as heat, this current will cause a huge damage to the 1239d motor drive thus a power transistor is needed.

The current is proportional to torque that the motor can provide.

\[ \tau = Kt \times I \]

*Equation 3 current torque relation*

The torque speed relation is shown on figure

![Torque-speed curve](image)

*Figure 3.13 torque-speed curve*

The torque-speed cure illustrates that the torque is reversely proportional to the speed. Which means if more torque is need this will cause the speed to go down if the input power is constant.
3.3 Software design

The software program used to compile the code was CODE VISSION.
CODE VISION is a powerful software for developing programs and with easy environment, it also provides a good helping tool to assist with developing the code like the wizard.

The wizard helps in carry out the initialization code and command.

![Figure 3.16 CODE VISION WIZARD](image)

The wizard was used to select the microcontroller, the microcontroller used was ATMEGA32, and the frequency of the microcontroller was set to 8MHZ.

The wizard was used to select the microcontroller, the microcontroller used was ATMEGA32, and the frequency of the microcontroller was set to 8MHZ.

After initialization is performed the delay function was developed.
3.4 Simulation

The overall system was represented using PROTUES 8.

Proteus 8 is an electronics circuit board design, PCB circuit board assembly and prototyping software that can also be used to for real time simulation of microcontroller, design of schematics of electronics and external electrical circuits and PCB design.

The system schematic design is shown on figure 3.17:
CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 RESULTS

A field test was done and the following result was obtained:

The temperature read by a thermometer was varying from 76.2°C to 120°C on a normal day on August 2017.

The system was designed and implemented. Readings were taken from the focal point of radiation at different times of the day and found that the temperature in the focus point is greater than 100 °C from 10 am to 3 pm when the weather is clear. From 9 am to 10 and from 3 pm to 4 pm the temperature is greater than 80 °C.

In the first period the concentrator can be used in cooking operations. In the second period, it cannot be used in cooking operations, but it can be used to heat water and prepared food.

4.2 DISCUSSIONS

5 The system implemented after the design of the mechanical components of the concentrator and its control system to move the concentrator 5 degrees every 20 minutes which maintain the focal point in a fixed position, enabling the use of thermal energy in heating and cooking.

6 This system uses an open loop control (passive) system so it is not possible to implement algorithms capable of dealing with cloudy or rainy weather.

7 Another drawback to using open loop system is that if a sudden change happened that affect the dish position, the system will not be able to restore the right position and hence making the focal point not to be in its expected place.

8 For a reflective surface, the dish was covered with stainless steel plates, increasing the weight of the system and thus increasing the mechanical torque needed to move it. It also caused a slight distortion in the focus point.
CHAPTER 5: CONCLUSIONS

5.1 Conclusions

A solar tracking system is designed and implemented using a microcontroller which move a parabolic dish to track the position of the sun and always facing it directly and that produce a fixed focal point.

5.2 Limitations

- The system cannot implement algorithms that are capable of dealing with cloudy and rainy weather.
- A high weight of the parabolic dish make it difficult to move.
- Small distortion happened to the focal point due to the usage of stainless steel to reflect the sun rays.

The system is not capable of performing cooking operations that require a very high temperature (e.g grilling).

5.3 Future Work:

The mechanism used in the tracking is a passive mechanism which means that the position of the dish might be inaccurate since the tracking is a function of time only and does not contain any feedback circuit to adjust the position of the parabolic dish, so the motor must be chosen carefully and the dish must face the sun perpendicularly before powering up the tracking system.

The mechanical design does not contain any breaking mechanism to stop the oscillation of the parabolic dish due the motor rotation, and this might cause the dish to be positioned wrong.

Covering the satellite dish with stainless steel to make it a reflecting surface adds more weight to the dish and thus a higher torque motor is needed, this might increase the cost of the system.
If more thermal energy is needed from the sun an alternative tracking algorithm could be used to track the sun more precisely with sensor and a control loop in the absence of the sun.
References

[1] MARLIYANI BINTI OMAR, “LOW COST SOLAR TRACKER.”


