بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College Graduate Studies

Control of Solar Tracking System

التحكم في نظام التتبع الشمسي

A Thesis Submitted In Partial Fulfillment of the Requirements for the

Degree of M.Sc. in Electrical Engineering(Control of microprocessors)

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December2015

الآية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (١) خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ (٢) اقْرَأْ وَرَبُّكَ الْأَكْرَمُ (٣) الَّذِي عَلَّمَ بِالْقَلَمِ (٤) عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ (٥)

سورة العلق من الآية ١ إلى ٥

DEDICATION

To my parents

To my family

To my teachers

To my friends

To any person help me to overcome any problem in my life

ACKNOWLEDGEMENT

First of all, I would like to thank Allah for giving me life, health and knowledge.

I so thankful to my supervisor ust .Abdallah Saleh for the extensive help and guidance he offered as a result of which I have overcome the difficulties that I face.

I would like to convey many thanks to the people who supported me throughout my work in this research especially my colleague Najlla Sideeg and the staff of school of Electrical and Nuclear Engineering, Sudan University of science and Technology.

ABSTRACT

The world population increases rapidly ,as a result power is needed. Power nowadays depends on traditional resources such as oil and coal, but these cause air pollution . So scientists begin to think of other resources of power, they produced electricity from renewable energy that is obtained from the sun and wind.

The solar power is the most important clean renewable power which is mainly found in hot countries. Besides technology that helps to produce electricity from solar power, is badly needed. The obstacle that faces producing the maximum amount of electricity, is the apparent movement of the sun that makes it change its position. The objective of this research is to design a solar tracking system to harness the maximum solar irradiance . A microcontroller is used to control the movement of the tracking system . The microcontroller is programmed to detect the sun light during the day by using Light Dependent Resisters(LDR) . Then a signal is sent to the stepper motor to control the movement of the solar panel to get the maximum solar irradiance. The result of the simulation obtained by protous program approved the efficiency of the system.

مستخلص

يزداد سكان العالم يوما بعد يوم مما يؤدى لزيادة الطلب على الطاقة. معظم الطاقة المنتجة تعتمد على المصادر التقليدية كالبترول والفحم . هذه المصادر تسبب تلوث البيئة لذلك اهتم العلماء بالاستفادة من مصادر الطاقة المتجددة والنظيفة كالرياح وضوء الشمس لتوليد الكهرباء . تعتبر الطاقة الشمسية من أهم مصادر الطاقة المتجددة لتوفرها خصوصا في الدول الحارة.إضافة لذلك توفر التكنولوجيا المستخدمة لتوليد الكهرباء من الطاقة الشمسية .ولكن المشكلة التي تعيق إنتاج اكبر قدر ممكن من الطاقة هو حركة الشمس وتغير موقعها خلال اليوم والسنة .الهدف الاساسى لهذا البحث تصميم نظام تتبع شمسي للحصول على اكبر قدر من ضوء الشمس .تم استخدام المتحكم الدقيق للتحكم في حركة النظام .ثم برمجة المتحكم الدقيق للكشف عن ضوء الشمس باستخدام مقاومة ضوئية متغيرة ثم يرسل إشارة لمحرك الخطوة لنحريك الألواح الشمسية للحصول على اكبر قدر من ضوء الشمس .نتائج المحاكاة المتحصل عليها باستخدام برنامج بروتوس برهنت على كفاءة النظام.

TABLE OF CONTENTS page

LIST of FIGURES

CHAPTER ONE

INTRODUCTION

Chapter one

Introduction

1.1 General

Automatic control system is situated among different aspect of applied branches of knowledge since it controls the production units in different industries and it control different types of vehicles and equipments. According to the development of the electronic science after the invention of transistor and integrated circuits, Electronic computer becomes very important in automatic control system and man could gain perfection in operation besides it has become more secured and it protect mankind from different accidents. This also leads to fewer burdens on human beings and difficult tasks have become easier for him.[4]

Solar energy can play a vital role in providing most of the heating, cooling and electricity needs in the world and also has the potential to solve our environmental problems. The sun is infinite and clean energy source and it sends to earth more than the world's energy consumption.[7]

1.2 Problem statement

A solar panel receives more sunlight when it is   perpendicular or parallel to the sun . But the direction of the sunlight always changes depends on the movement of the sun in day

1.3 Objectives

-To study and understand solar energy.

-To study main components such as microcontroller and stepper motor.

-To build complete solar tracking system using proteus software.

-To evaluate the performance of solar tracking system.

1.4 Methodology

-Study and understand the previous works

-Contract the simulation model using proteus software

-Evaluate the performance of solar tracking system based on simulation results.   .

1.5 Thesis Outline

This thesis is presented in five chapters. The scope of each chapter is explained as follows: Chapter on gives an introduction including general concepts, problem statement ,objectives and methodology .Chapter two presents literature review of previous works, control system, the main components such as microcontroller and stepper motor. Chapter three introduces the solar tracking system. Various solar tracking systems types are discussed. Different programming languages are then presented. Chapter four includes the simulation results and discussion. Chapter five contains the conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

CHAPTER TWO

LITERATURE REVIEW

2.1 The previous works

 The output power produced by high-concentration solar thermal and photovoltaic systems is directly related to the amount of solar energy acquired by the System, and it is therefore necessary to track the sun's position with a high degree of accuracy. This paper presents sun tracking generating power system designed and implemented in real time. A tracking mechanism composed of photovoltaic module, stepper motor ,sensors, input/output interface and expert Fuzzy Logic Control(FLC) implemented on Fuzzy Programmable(FPGA), that to track the sun and keep the solar cells always face the sun in most of the day time. The proposed sun tracking fuzzy controller has been tested using Matlab/Simulink program; the simulation results verify the effectiveness of the proposed controller and shows an excellent result [1].

This study focuses on the mechatronic engineering aspects in the design and development of a dynamic mechatronic platform and digital electronic control system for the stand-alone concentrating solar power system. Design specifications require an accurate automatic positioned and control system for a motorized parabolic solar reflector with an optical solar harnessing capacity of 12 kW at solar noon. It must be suitable for stand-alone rural power generation.

This study presents a conceptual design and engineering prototype of a balanced cantilever tilt-and-swing dual-axis slew drive actuation means as mechatronic solar tracking mobility platform for a 12 m2 lightweight

parabolic solar concentrator. Digital automation of the concentrated solar platform is implemented using an industrial Siemens S7-1200 Programmable Logic Controller (PLC) with digital remote control interfacing, pulse width modulated direct current driving, and electronic open loop/closed loop solar tracking control. The design and prototype incorporates off-the-shelf components to support local manufacturing at reduced cost and generally meets the goal of delivering a dynamic mechatronic platform for a concentrating solar power system that is easy to transport, assemble and install at remote rural sites in Africa. Real-time experiments, conducted in the summer of South Africa, validated and established the accuracy of the engineering prototype positioning system. It shows that the as-designed and -built continuous solar tracking performs to an optical accuracy of better than $1.0\circ$ on both the azimuth and elevation tracking axes; and which is also in compliance with the pre-defined design specifications [2].

Design and execution of a solar tracker system dedicated to the PV conversion panels. The proposed single axis solar tracker device ensures the optimization of the conversion of solar energy into electricity by properly orienting the PV panel in accordance with the real position of the sun. The operation of the experimental model of the device is based on a Direct Current (DC) motor intelligently controlled by a dedicated drive unit that moves a mini PV panel according to the signals received from two simple but efficient light sensors. The performance and characteristics of the solar tracker are experimentally analyzed [3].

2.2 Control System

Control engineering is based on the foundations of feedback theory and linear system analysis, and it generates the concepts of network theory and

communication theory. Accordingly, control engineering is not limited to any engineering discipline but is applicable to aeronautical, chemical, mechanical, environmental, civil, and electrical engineering. control system is an interconnection of components forming a system configuration that will provide a desired system response. The basis for analysis of a system is the foundation provided by linear system, which assumes a cause effect relationship for the components of a system. A component or process to be controlled can be represented by a block as shown in Figure2.1.[4]
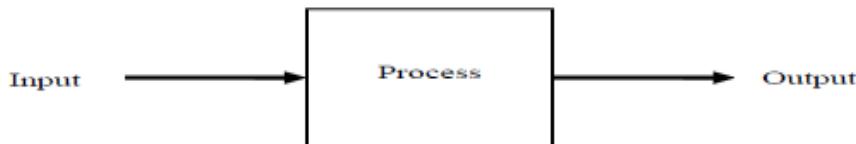
Figure (2.1) : Process under control

An open-loop control system utilizes a controller or control actuator to obtain the desired response as shown in Figure (2.2) the open-loop control system utilizes an actuating device to control the process directly without using device. An example of an open-loop control system is an electric toaster
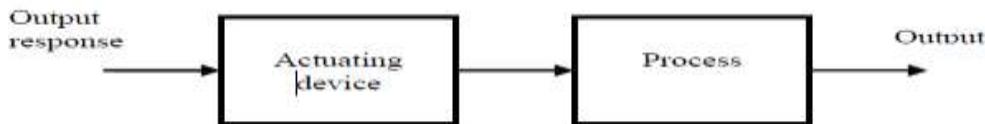
Figure 2.2: Open-loop control system

A closed-loop control system (Figure 2.3) utilizes an additional measure of the actual output to compare the actual output with the desired output response. The measure of the output is called the feedback signal. A feedback control system is a control system that tends to maintain a

relationship of one system variable to another by comparing functions of these variables and using the difference as a means of control. As the system is becoming more complex, the inter relationship of many controlled variables may be considered in the control scheme. An example of closed-loop control system is a person steering automobile by looking at the auto's location on the road and making theappropriate adjustments.[4]
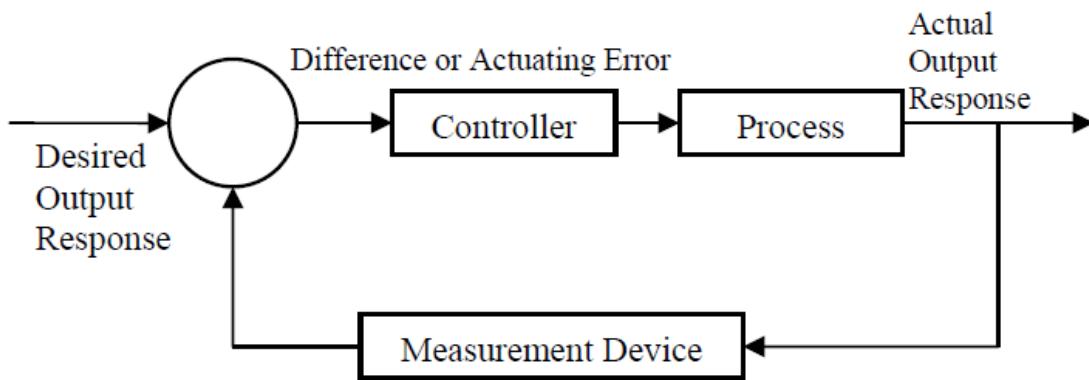
Figure2.3: Closed loop control system

2.2.1 Type of control theory

The main type of control theory are:

*Conventional Theory

The conventional theory depends on representing the control system by Laplace variable ,and also depends on the relation between input and output only by the transfer function and it`s exposed to the internal variables of the system (state variables). This is considered as limitations and short coming in the conventional theory besides another limitation and short

coming which is initial condition that equal zero, it can be applied in the design by the root locus or frequency response on the input, output systems only, and the way of the design by the trial and error.[4]

*Modern control theory

The modern control theory is considered as the most suitable entry to the multi input and output control systems. it does consist of a large number of variables and it can be used in all the linear systems of the single input and single output and the multi input multi output system. The modern control theory is suitable also for non-linearity systems. The conventional theory versus the control theory. The control operation in the conventional theory depends only on the feedback of the output without considering the internal variables of the system, this limitation and short coming can be avoided in the modern control theory where the controlled by the feedback of the output and the internal variables in the same time, this guarantee that it doesn't change these system variables according to the targeted aims during the control operation.[4]

2.2.2 Role of control theory

To design a controller that makes a system behave in a desirable manner, we need a way to predict the behavior of the quantities of interest over time, specifically how they change in response to different inputs. Mathematical models are most often used to predict future behavior, and control system design methodologies are based on such models. Understanding control theory requires engineers to be well versed in basic mathematical concepts and skills, such as solving differential equations and using Laplace transform. The role of control theory is to help us gain insight on how and why feedback control systems work and how to systematically deal with

7

various design and analysis issues. Specifically, the following issues are of both practical importance and theoretical interest:

1. Stability and stability margins of closed-loop systems.

2. How fast and smooth the error between the output and the set point is driven to zero.

3. How well the control system handles unexpected external disturbances, sensor noises, and internal dynamic changes.

In the following, modeling and analysis are first introduced, followed by an overview of the classical design methods for single-input single-output plants, design evaluation methods, and implementation issues. Alternative design methods are then briefly presented. Finally, For the sake of simplicity and brevity, the discussion is restricted to linear, time invariant systems. Results may be found in the literature for the cases of linear, time-varying systems, and also for nonlinear systems, systems with delays, systems described by partial differential equations, and so on; these results, however, tend to be more restricted and case dependent.[4]

2.3 Microcontroller

A microcontroller already contains all components which allow it to operate stand alone, and it has been designed in particular for monitoring and/or control tasks. In consequence, in addition to the processor it includes memory, various interface controllers, one or more timers, an interrupt controller, and last but definitely not least general purpose Input /Output(I/O) pins which allow it to directly interface to its environment. Microcontrollers also include bit operations which allow to change one bit within a byte without touching the other bits.[5]

The basic internal designs of microcontrollers are pretty similar. Figure (2.4) shows the block diagram of a typical microcontroller. All components

are connected via an internal bus and are all integrated on one chip. The modules are connected to the outside world via I/O pins.
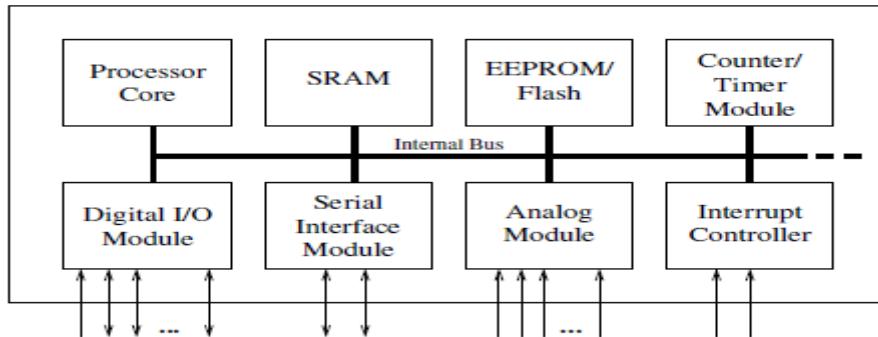
Figure2.4: Basic layout of microcontroller

The main component of microcontroller are: .

(1) Processor core: The Central Process Unit (CPU) of the controller. It contains the arithmetic logic unit, the control unit, and the registers such as stack pointer, program counter, accumulator register, register file.

(2)Memory: The memory is sometimes split into program memory and data memory. In larger controllers, a Direct Memory Access(DMA) controller handles data transfers between peripheral components and the memory.

(3) Interrupt controller: Interrupts are useful for interrupting the normal program flow in case of (important) external or internal events. In conjunction with sleep modes, they help to conserve power.

(4) Timer/counter: Most controllers have at least one and more likely 2-3 Timer/counters, which can be used to timestamp events, measure intervals, or count events. Many controllers also contain Pulse Width Modulation(PWM) outputs, which can be used to drive motors or for safe breaking (antilock brake system, ABS). Furthermore, the PWM output can

be conjunction with an external filter to realize a cheap digital/analog converter.

(5) Digital I/O: Parallel digital I/O ports are one of the main features of microcontrollers. The number of I/O pins varies from 3-4 to over 90, depending on the controller family and the controller type.

(6) Analog I/O: Apart from a few small controllers, most microcontrollers have integrated analog/digital converters, which differ in the number of channels (2-16) and their resolution (8-12 bits). The analog module also generally features an analog comparator. In some cases, the microcontroller includes digital/analog converters.

(7) Interfaces: Controllers generally have at least one serial interface which can be used to download the program and for communication with the development Personal Computer(PC) in general. Since serial interfaces can also be used to communicate with external peripheral devices, most controllers offer several and varied interfaces like Serial Peripheral Interface (SPI) and Serial Communication Interface (SCI).

Many microcontrollers also contain integrated bus controllers for the most common (field) busses. Inter_ Integrated Circuit (IIC) and Controller Area Network(CAN) controllers lead the field here. Larger microcontrollers may also contain Universal Serial Bus(USB), or Ethernet interfaces.

(8) Watchdog timer: Since safety-critical systems form a major application area of microcontrollers, it is important to guard against errors in the program and/or the hardware. The watchdog timer is used to reset the controller in case of software crashes.

(9) Debugging unit: Some controllers are equipped with additional hardware to allow remote debugging of the chip from the PC. So there is no need to download special debugging software, which has the distinct advantage that erroneous application code cannot overwrite the debugger.

Microcontrollers differ from microprocessors in a lot of ways. Microprocessors required external hardware and peripherals such as Random Access Memory(RAM),Read-only Memory (ROM),whereas Microcontrollers are designed to perform a particular task which is very similar to a computer as they have in-built program and data memory and required few external hardware. They are designed on the concept of System On Chip(SOC) and all the components designed to include in one chip.[5]

2.3.1 Microcontroller architecture

It emphasizes high integration, in contrast to a microprocessor which only contains a CPU (the kind used in a PC). In addition to the usual arithmetic and logic elements of a general purpose microprocessor, the microcontroller integrates additional elements such as read-write memory for data storage, read-only memory for program storage, flash memory for permanent data storage, peripherals, and input/output interfaces. At clock speeds of as little as 32KHz, microcontrollers often operate at very low speed compared to microprocessors, but this is adequate for typical applications. They consume relatively little power (mill watts or even microwatts), and will generally have the ability to retain functionality while waiting for an event such as a button press or interrupt. Power consumption while sleeping (CPU clock and peripherals disabled) may be just nano watts, making them ideal for low power and long lasting battery applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, appliances, power tools, and toys. By reducing the size, cost, and power consumption compared to a design using a separate microprocessor,

memory, and input/output devices, microcontrollers make it economical to electronically control many more processes.[5]

2.3.2 Programs

Microcontroller programs must fit in the available on-chip program memory, since it would be costly to provide a system with external, expandable, memory. Compilers and assembly language are used to turn high-level language programs into a compact machine code for storage in the microcontroller's memory. Depending on the device, the program memory may be permanent, read-only memory that can only be programmed at the factory, or program memory may be field-alterable flash or erasable read-only memory.[5]

2.3.3 Programming environments

Microcontrollers were originally programmed only in assembly language, but various high-level programming languages are now also in common use to target microcontrollers. These languages are either designed especially for the purpose, or versions of general purpose languages such as the C programming language. Compilers for general purpose languages will typically have some restrictions as well as enhancements to better support the unique characteristics of microcontrollers. Some microcontrollers have environments to aid developing certain types of applications. Microcontroller vendors often make tools freely available to make it easier to adopt their hardware.[5] Many microcontrollers are so quirky that they effectively require their own non-standard dialects of C, such as Serial Data Communication(SDCC) for the 8051, which prevent using standard tools (such as code libraries or static analysis tools) even for code unrelated to hardware features. Interpreters are often used to hide such low level quirks.

Interpreter firmware is also available for some microcontrollers. Simulators are available for some microcontrollers, such as in microchip's MPLAB environment. These allow a developer to analyze what the behavior of the microcontroller and their program should be if they were using the actual part. A simulator will show the internal processor state and also that of the outputs, as well as allowing input signals to be generated. While on the one hand most simulators will be limited from being unable to simulate much other hardware in a system, they can exercise conditions that may otherwise be hard to reproduce at will in the physical implementation, and can be the quickest way to debug and analyze problems.[5]

2.3.4 Atmel AVR

The A VR Modified Harvard architecture 8-bit Reduced Instruction set computer (RISC) single chip microcontroller (µC) which was developed by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to one-time programmable ROM, Erasable Programmable Read Only Memory(EPROM), or Electrical Erasable Programmable Only Memory (EEPROM) used by other microcontrollers at the time. Note that the use of "AVR" in this article generally refers to the 8-bit RISC line of Atmel AVR Microcontrollers. Among the first of the AVR line was the AT90S8515, which in a 40-pin Dual In Pin(DIP) package has the same pin out as an 8051 microcontroller, including the external multiplexed address and data bus. The polarity of the RESET line was opposite (8051's having an active-high RESET, while the AVR has an active-low RESET), but other than that, the Pin out was identical. Figure 2.5 shows the AVR Atmega16 microcontroller and its pin configurations.
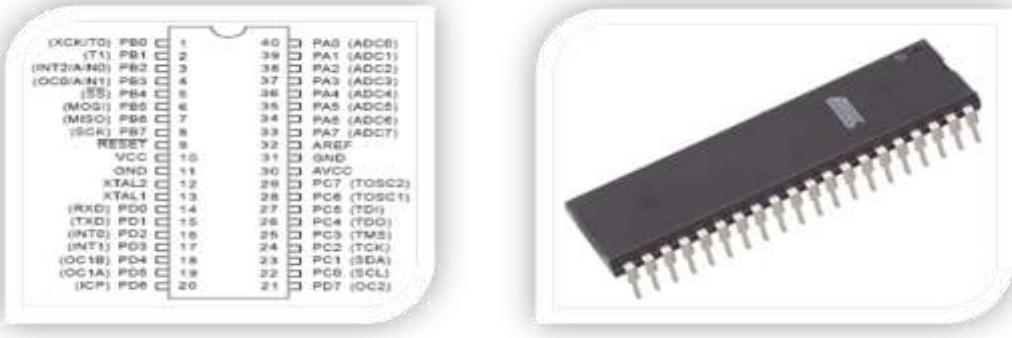
Figure 2.5: AVR Atmega16   microcontroller

Where:

VCC: Digital supply voltage.

GND: Ground.

Port A (PA7...PA0): Port A serves as the analog inputs to the Analog to Digital(A/D)Converter. Also port A serves as an 8-bit bi-directional I/O port, if the A/D converter is not used.

Port B (PB7...PB0): Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit).

Port C (PC7...PC0): Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit).

Port D (PD7...PD0): Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit).

RESET input: A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running.

XTAL1: Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

XTAL2: Output from the inverting oscillator amplifier.

AVCC: AVCC is the supply voltage pin for port A and the A/D Converter. It should be externally connected to VCC, even if the A/D is not used. If the A/D is used, it should be connected to VCC through a low-pass filter.

AREF: is the analog reference pin for the A/D converter.[6]

2.4 Stepper Motor

A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. 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 motors rotation has several direct relationships to these applied input pulses. 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**.** Figures 2.6 and 2.7 show stepper motor and stepper motor wiring ,respectively.[9]


Figure2.6: Stepper motor
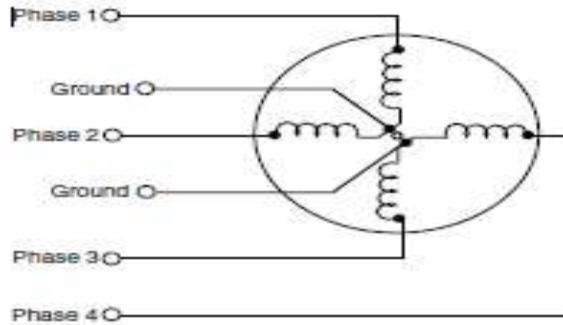
Figure 2.7: Stepper motor wiring

2.4.1 Advantages

1. The rotation angle of the motor is proportional to the input pulse.

2. The motor has full torque at standstill (if the windings are energized).

3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3 − 5% of a step and this error is non-cumulative from one step to the next.

4. Excellent response to starting/ stopping/reversing.

5. Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependent on the life of the Bearing.

6. One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Motor position is known simply by keeping track of the input step pulses

7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.

8. A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.[9]

2.4.2 Disadvantages

1. Resonances can occur if not properly controlled.

2. Not easy to operate at extremely high speeds.

2.4.3 Stepper Motor Types

There are three basic of stepper motor types as

• Variable-reluctance.

• Permanent-magnet.

• Hybrid.

2.4.4 Application of stepper motor

A stepper motor can be a good choice whenever controlled movement is required. They can be used to advantage in applications control rotation angle, speed, position and synchronism are needed. Because of the inherent advantages listed previously, stepper motors have found their place in many different applications. Some of these include printers, plotters, high end office equipment, hard disk drives, medical equipment.[9]

2.5 Light Dependent Resisters

Light Dependent Resistors (LDRs) are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically.Figure2.8 shows the LDR.[9]
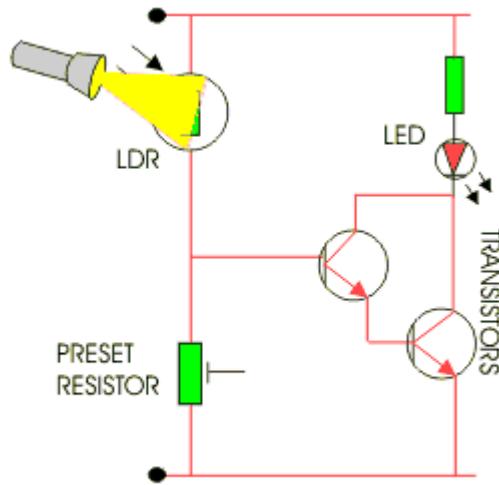
Figure 2.8:LDR

2.6 Voltage Regulator

A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more Alternating Current(AC) or DC voltages show in fig (2.9).
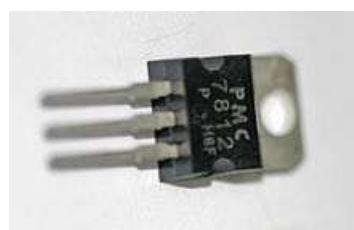
Figure 2. 9: Voltage regulator

Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and

other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.[10]

2.7 Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals. Thus, the ratio of the voltage applied across a resistor's terminals to the intensity of current through the circuit is called resistance

2.8 Liquid Crystal Display

Liquid Crystal Display (LCD) is an electro-optical amplitude modulator realized as a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. A comprehensive classification of the various types and electro-optical modes of LCDs is provided in the article LCD classification.Figures2.10 and 2.11 show the LCD and it interface to microcontroller, respectively.[6]


Figure 2.10: LCD
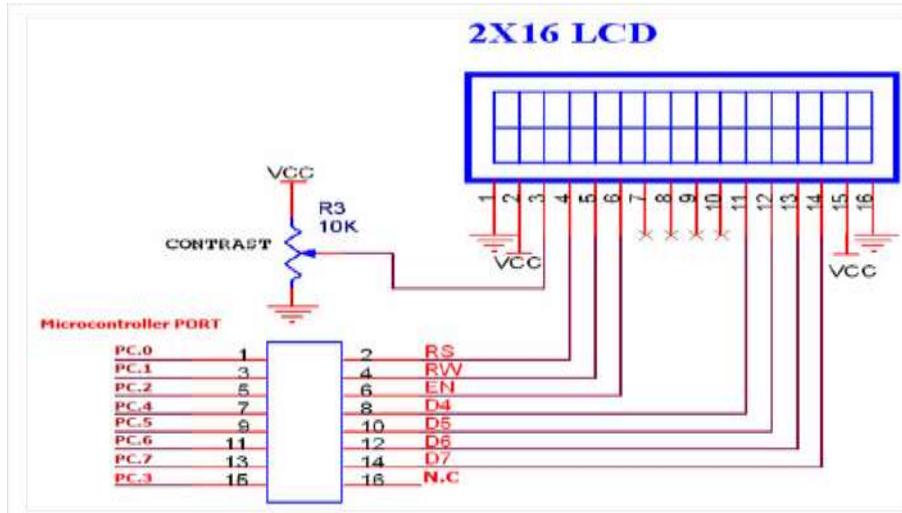
.   Figure 2.11: LCD interface to microcontroller

2.9 ULN2804

The ULN2804 is a high voltage, high current Darlington array comprised of eight NPN Darlington pairs. The device features open-collector outputs with suppression diodes for inductive loads and is ideally suited for interfacing between low-level logic circuitry and high power loads. Typical loads including relays DC motors, filament lamps, Light Emitting Diode(LED) displays, printer hammers and high power buffers.

 Features of ULN 2804:

> Eight Darlington with common emitters.

> TTL, PMOS or CMOS compatible inputs.

> Peak output current to 500mA.

> Output voltage to 50V.

Figure2.12 shows the pin configuration of ULN2804.[9]
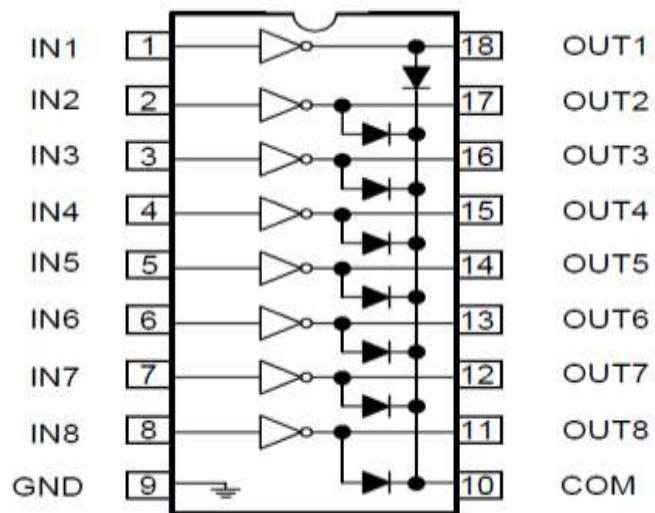
Figure 2.12: ULN2804

CHAPTER THREE

TRACKING SYSTEM

CHAPTER THREE

TRACKING SYSTEM

3.1 Tracking System Technique

Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. The system will tend to maximize the amount of power absorbed by Photo Voltaic (PV) systems Generally tracking is the observing of persons or objects on the move and supplying a timely ordered sequence of respective location data to a model such capable to serve for depicting the motion on a display capability. A solar tracker is a generic term used to describe devices that orient various payloads toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices.[7]

Currently there are several available forms of sun tracking. There are two general forms of tracking used which is fixed control algorithms and dynamic tracking. The difference between these two methods is the manner in which the path of the sun is determined. In fixed control algorithms, the path of the sun is determined by referencing an algorithm that calculates the position of the sun for each time period. Control system does not actively find the sun's position but work it out given the current time, day, month and year. On the other hand, the dynamic tracking system actively searches for the sun's position at any time of the day. Common to both forms of tracking is the control system. This system consists of some method of direction control, such as DC motors, stepper motors, and servo motors, which are directed by a control circuit, either digital or analog.

 Since the sun's position in the sky changes with the seasons and the time of day, trackers are used to align the collection system to maximize energy

production. Several factors must be considered when determining the use of trackers. Some of these include: the solar technology being used, the amount of direct solar irradiation, feed-in tariffs in the region where the system is deployed, and the cost to install and maintain the trackers.[7]

3.1.1 Single axis

Solar trackers can either have a horizontal or a vertical axis. The horizontal type is used in tropical regions where sun gets the very high at noon, but the days are short. The vertical type is used in where the high latitudes sun does not get very high, but summer days can be very long. In concentrated solar power applications, single axis trackers are used with parabolic and linear Fresnel mirror designs.Figure3.1 shows the single axis tracker.[8]

Figure 3.1 Single axis

3.1.2 Dual axis

Solar trackers have both a horizontal and a vertical axis and thus they can track the sun's apparent motion virtually anywhere in the world. Concentrating Solar Power (CSP) applications using dual axis tracking include solar power towers and dish (Stirling engine) systems. Dual axis tracking is extremely important in solar tower applications due to the angle errors resulting from longer distances between the mirror and the central receiver located in the tower structure. Many traditional solar PV

applications employ two axis trackers to position the solar panels perpendicular to the sun's rays. This maximizes the total power output by keeping the panels in direct sunlight for the maximum number of hours per day. Figure3.2 shows the dual axis tracker.[8]

Figure 3.2: Dual axis

3.2 Sun Tracker

Sun rises each day from the east, and moves across the sky to the west. When the sun shining, it is sending energy to the earth, and we can feel it's as heat; however and its position varies with the time of day and the seasons. Thus, if we could get a solar cell to turn and look at the sun all day, then it would be receiving the maximum amount of sunlight possible and converting it into electricity. Solar tracker is a device that is used to align a single photovoltaic panel or an array of PV modules with the sun, so a solar tracker can improve a systems power output by keeping the sun in focus throughout the day; thus improving effectiveness of such equipment over any fixed position.A well designed system which utilizes a tracker will reduce an initial implementation cost, since it needs fewer expensive panels due to increased efficiency.[7]

Since Sun tracking systems are broadly classified in two types; photovoltaic panel tracking and solar thermal plants. For the purpose of this project the formal type that was used is PV type, which enables the position of the PV panel to be controlled using electrical drives so to always face it perpendicular to sun rays. PV panels are themselves the mode of generating power. Figure (3.4) show the general photo voltage system which consist of the following component:

(1) LDR : is used to get input data of light

(2) Analog to digital converter: is used to convert the analog data by the LDR sensor into digital data

(3) Microcontroller(MC):is used to receive the data from the LDR, then it give the instruction to the stepper motor for tracking.

(4) ULN2804:is used to peak the input current to drive the stepper motor.

(5)Stepper motor: Is an electromechanical device which converts electrical pulses into discrete mechanical movement. Using the direct the panel towards the sun.

(6)Solar panel: All the system works to keep the solar panel direct towards the solar panel generate the DC voltages

(8) PV :is used to conversion of solar light into to electricity.[9]
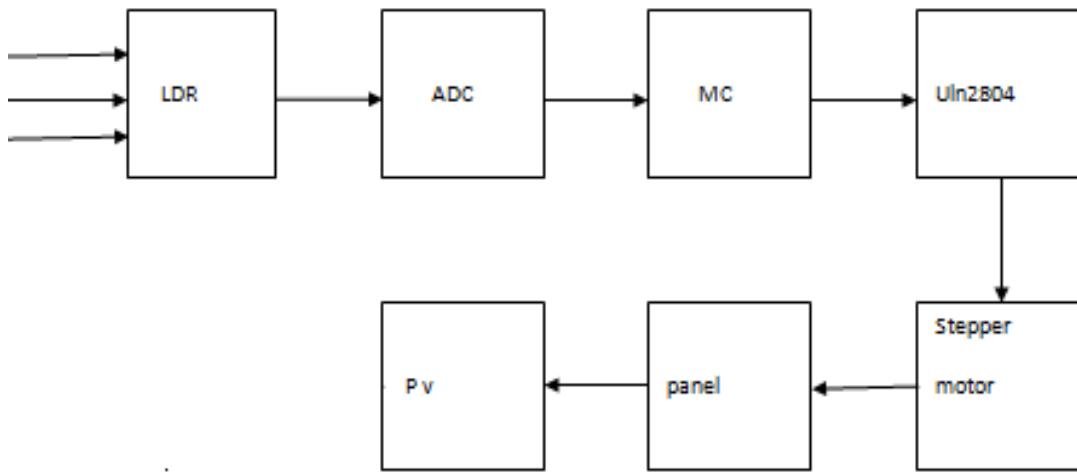
Figure 3.3: General block diagram of solar tracker system

3.3 Solar Power Fundamentals

A fundamental understanding of how a photovoltaic panel works is essential in producing a highly efficient solar system. 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 silicone are gaining popularity. [10]

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 can't jump to the

26

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. 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. Figure3.4 shows the angle of incidence to solar cell.
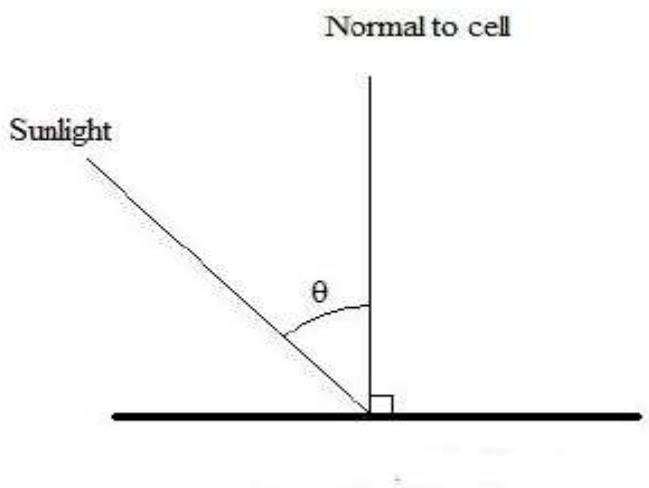

Figure 3. 3: Angle of incidence to solar cell

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 (θ). Assuming the sunlight is staying at a constant intensity (k) the available sunlight to the solar cell for power generation (W) can be calculated as:

W=A k cos (θ)……………………….…………………….(3.1)

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.[10]

3.4 Existing Tracking Technology

PV panel is dependent on its angular position to the sun. A PV panel must be perpendicular to the sun for maximum solar absorption, which is done by using a tracking system. Multiple tracking systems exist, which vary in reliability, accuracy, cost, and other factors. A tracking system must be chosen wisely to ensure that the tracking method increases the power gained instead of decreasing it.[10]

3.5 Programming Languages

Programmers write instructions in various programming languages, some directly understandable by computers and others that require intermediate Translation steps. Hundreds of computer languages are in use today. These may be divided into three general types .as follows

(1)Machine languages

(1) Assembly languages

(2) High level languages

Any computer can directly understand only its own machine language is design of that computer. Machine languages generally consist of strings of numbers that instruct computers to perform their most elementary operation one at time. Machine language programming was simply too slow and tedious for most programmers. Instead of using the strings of numbers that computers could directly understand, programmer began

using English like abbreviation to represent elementary operations. These abbreviation formed the basis of assembly languages. Translator programs called assemblers were developed to convert assembly language programs to machine language.

Computer usage increased rapidly with the advent of assembly languages, but programming in these still required many instructions to accomplish even the simplest tasks. To speed the programming process, high level language were developed in which single statements could be written to accomplish substantial task. The translator programs that convert high level language programs into machine language are called compilers. The process of compiling a high level language programs into machine language can take a considerable amount of computer time interpreter programs were developed to execute high level language programs directly without the need for compiling those program into machine language. although compiled programs execute much faster than interpreted programs, interpreters are popular in program development environments in which programs are recompiled frequently as features are added and errors are corrected.[5]

CHAPTER FOUR

SIMULATION AND RESULTS

CHAPTER FOUR

SIMULATION AND RESULTS

4.1 Simulation Diagram

The simulations are done for solar tracker system using the proteus software . the complete simulation diagram is show in figure (4.1):
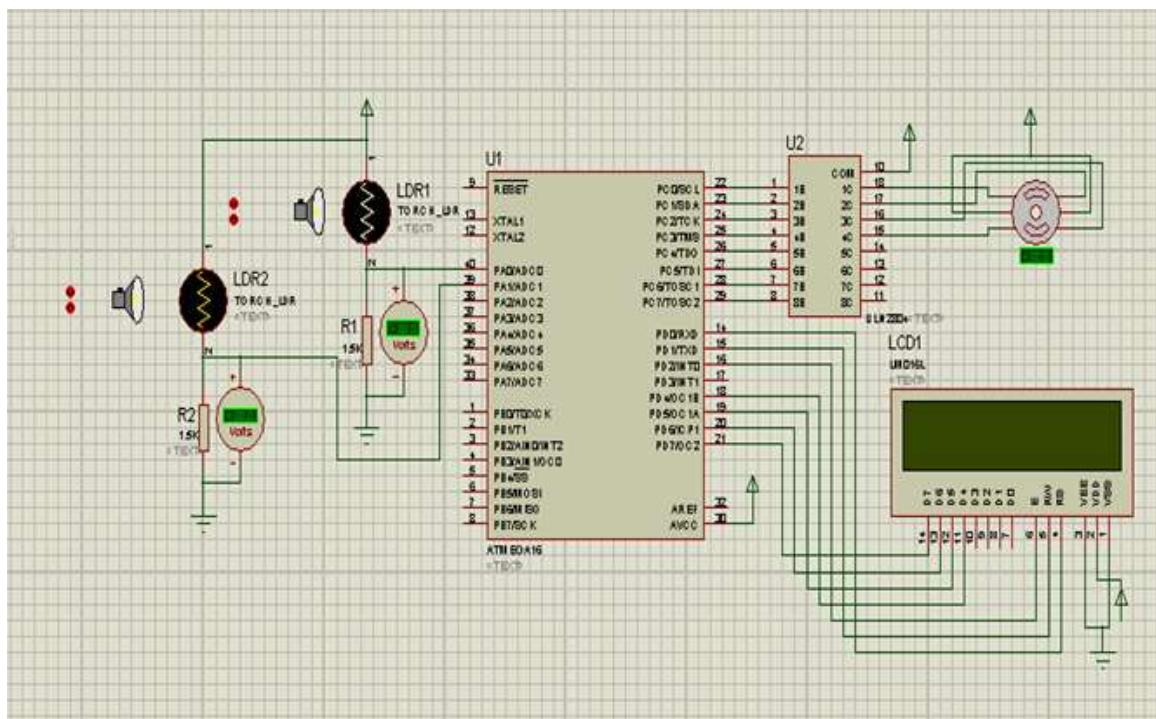
Figure 4.1:Complete simulation diagram

4.2 Results

The Light dependent resister (LDR1) used to show the availability of sun shine. The setting point is 3V when the volt exceed 3V that mean the sun is shining, and if the volt is below 3V means there is no sun (darkness), when the volt reading exceed 3V the LDR2 will be in function**.**Figure4.2 shows

the sun shining when the setting point equal to 3V . Figure4.3 shows the sun darkness when the setting point below 3V.
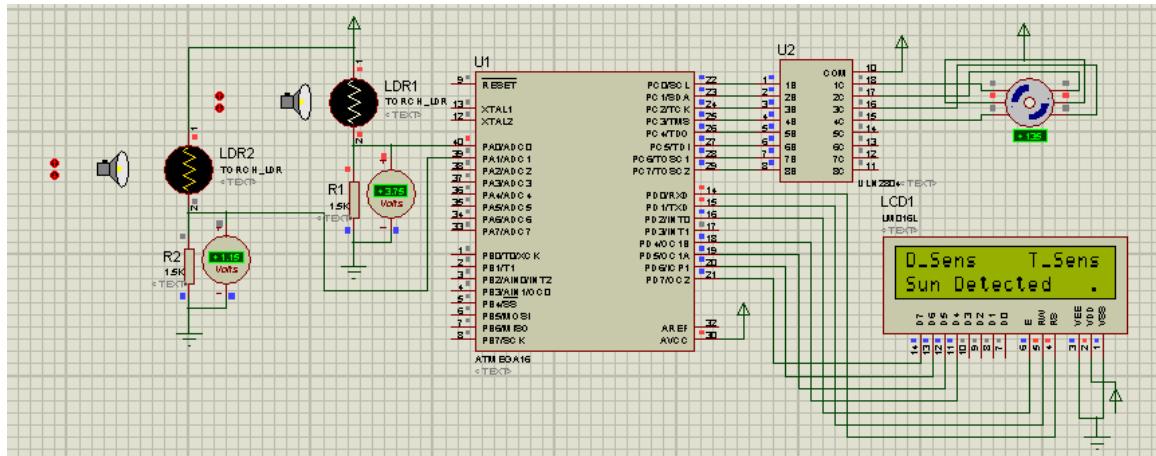

Figure 4.2: The sun shining when the setting point is equal to 3V
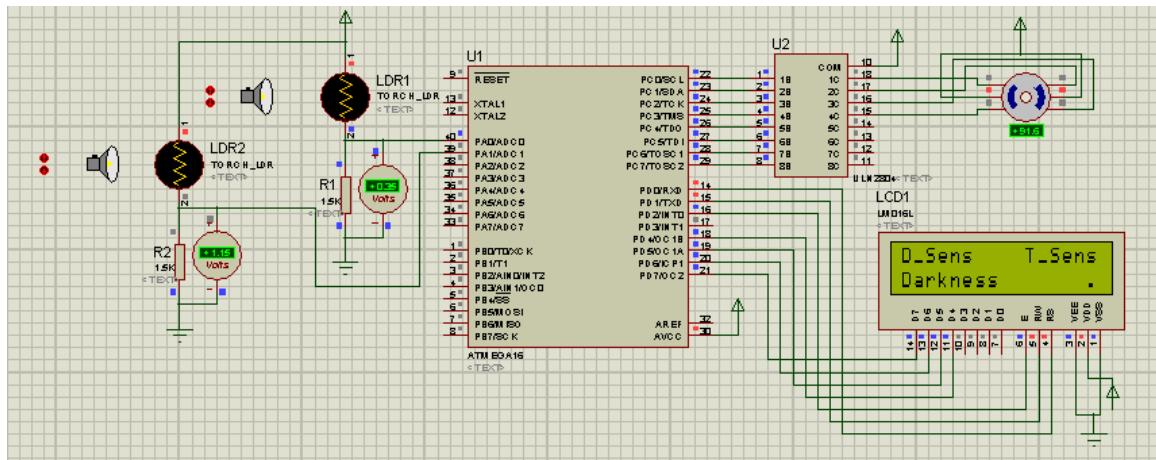
Figure 4.3: The sun darkness when the setting point below 3V

 When LDR1 is 3V and LDR2 is less then 2.1V the motor start to move the photo voltaic cell to treade the sun location as shown in figure4.4
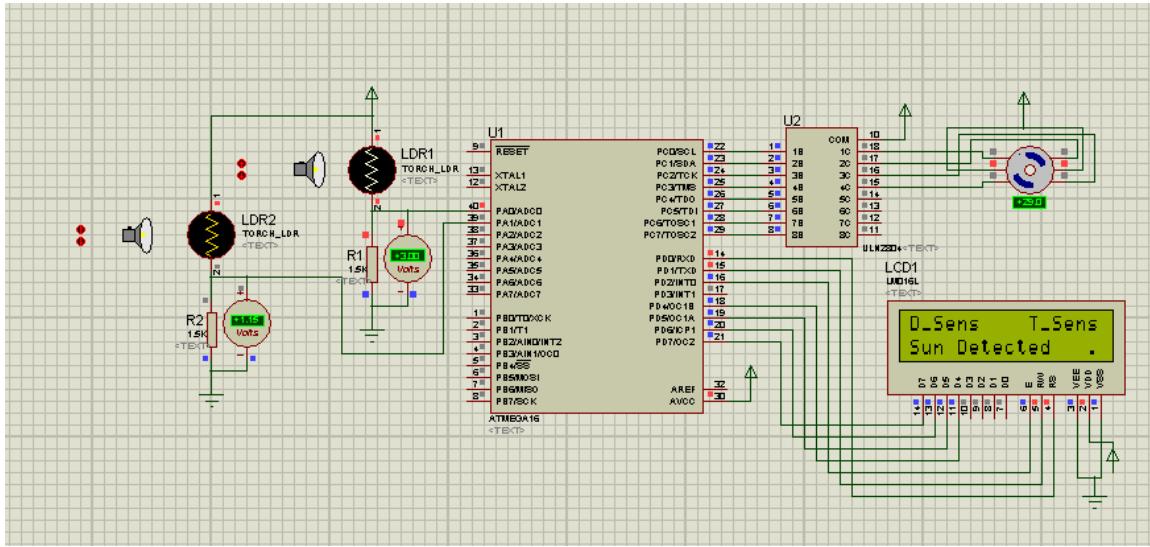
Figure 4.4 The motor start to tracks the sun movement when the LDR1 is 3Vand LDR2 is below 2.1V

Figure 4.5 shows the motor will stop tracking the sun when LDR1 equal to 3V and LDR2 reach to2.1V
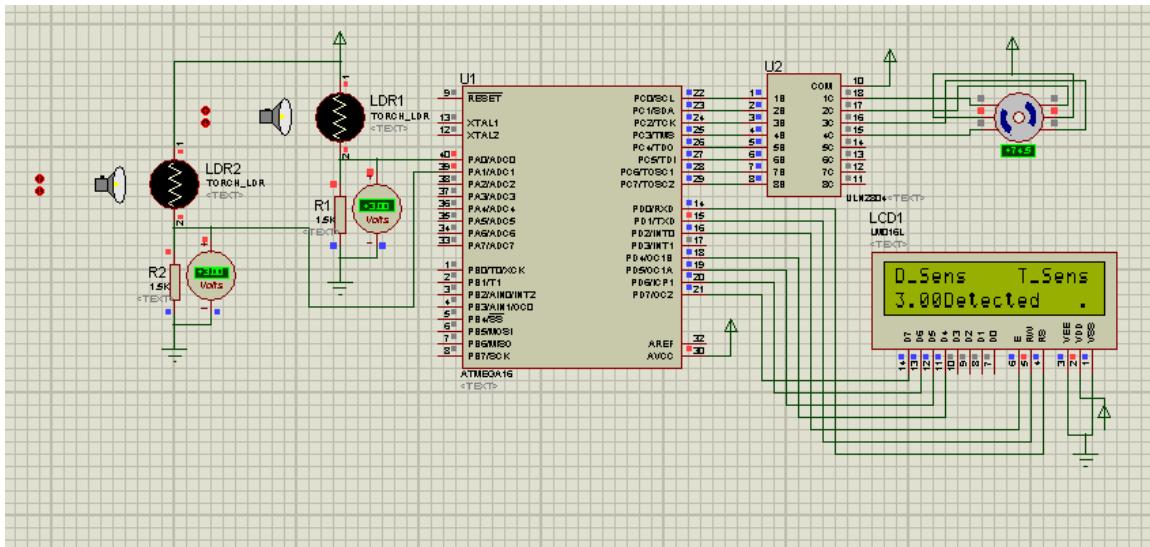
Figure 4.5: The motor stop to track when the LDR1 is 3V and LDR2 is reaches to 2.1V

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

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CONCLUSION AND RECOMMENDATION

5.1 Conclusion

One of the most important problem facing the world today is energy problem. Most of energy production is dependent on fossil fuels like oil and coal. These main sources of fossil fuels are expected to end up from the world during the recent century. Therefore, renewable energy replaces the conventional fuels for producing electricity. Renewable energy is energy which comes from natural resources such as sunlight ,wind, tides and waves. Solar energy is one of the most popular renewable sources now a days. In thesis a solar tracking system has been developed to increase the amount of power generated by the solar panel . An Atmega16 microcontroller is used to control the movement of the solar panel. The complete simulation diagram of the solar tracker system is built using proteus software. A series of simulation studies have been conducted in order to evaluate the performance of the solar tracker system. The simulation result s show good performance of the solar tracker system controlled by microcontroller.

5.2 Recommendations

-To use PID controller for tracking the sun location for maximum power.

- To use fuzzy logic for tracking the sun location.

-To use fixed control algorithms and compare the result of dynamic system.

References

[1] Basil Hamed, "Fuzzy Controller Design Using FPGA for Sun Tracking In Solar Array System" , Published online February 2012.

[2] Qerhardus Johannes Prinsloo, "Automatic Positioner and Control System for Amotorized Parabolic Solar Reflector", Stellenbosch University, December 2014.

[3] Tiberiu Tudorache1, Liviu Kreindler1, "Design of a Solar Tracker System for PV Power Plants", University Politehnica of Bucharest, Romania, June-2013.

[4] Araki M. , "Control Systems, Robotics, And Automation," Encyclopediaof Life Support Systems (EOLSS), Vol. 2,1993

[5]Kenneth J. Ayala, "The microcontroller Artitecture ,programming and Application",Western Carolina University,1991.

[6]Atmel Corporation, "8-bit AVR Microcontroller", Atmel Logo and combination thereof, 2010

[7] Gansu Natural Energy Research Institute," Solar Energy Application Technologies", International solar Energy Application Training Workshop , 2011.

[8] Tsung-Yu Tsai, "Study the Difference of Solar Electricity Generation between the Fixed-Angle and Dual-Axis Tracker Systems" , Taiwan, R.O.C., 2006

[9] Arindam Bose, "The Solar Tracking System", Future institute 2011.

[10] Adrian catarius ,"Azimuth-Altitude dual axis solar tracker",December 2010.

APPENDIX SIMULATION PROGRAM

APPENDIX SIMULATION PROGRAM

```c
#include <mega16.h>

#include <delay.h>

#include <string.h>

#include <stdio.h>

#include <stdlib.h>

#include <math.h>

#asm

   .equ __lcd_port=0x12 ;PORTD

#endasm

#include <lcd.h>

#define ADC_VREF_TYPE 0x60

{

ADMUX=adc_input|ADC_VREF_TYPE;

ADCSRA|=0x40;

while ((ADCSRA & 0x10)==0);

ADCSRA|=0x10;

return ADCH;

}
```

```c
unsigned int x1,x2;

float volt1,volt2;

int i;

char lcdbuffer[16];

void main(void)

{

PORTA=0x00;

DDRA=0x00;

PORTB=0x00;

DDRB=0x00;

PORTC=0x00;

DDRC=0xFF;

PORTD=0x00;

DDRD=0x00;

TCCR0=0x00;

TCNT0=0x00;

OCR0=0x00;

TCCR1A=0x00;

TCCR1B=0x00;
```

```
TCNT1H=0x00;

TCNT1L=0x00;

ICR1H=0x00;

ICR1L=0x00;

OCR1AH=0x00;

OCR1AL=0x00;

OCR1BH=0x00;

OCR1BL=0x00;

ASSR=0x00;

TCCR2=0x00;

TCNT2=0x00;

OCR2=0x00;

MCUCR=0x00;

MCUCSR=0x00;

TIMSK=0x00;

ACSR=0x80;

SFIOR=0x00;

ADMUX=ADC_VREF_TYPE;

ADCSRA=0x87;
```

```c
// LCD module initialization

lcd_init(16);

while (1)

   {

   start:

   lcd_gotoxy(0,0);

   lcd_putsf("Sun Tracking Sys");

   delay_ms(100);

   lcd_gotoxy(0,1);

   lcd_putsf("Please Wait.    ");

   delay_ms(50);

   lcd_gotoxy(0,1);

   lcd_putsf("Please Wait..   ");

   delay_ms(50);

   lcd_gotoxy(0,1);

   lcd_putsf("Please Wait...  ");

   delay_ms(50);

   lcd_gotoxy(0,1);

   lcd_putsf("Please Wait.... ");
```

```
delay_ms(50);

lcd_gotoxy(0,1);

lcd_putsf("Please Wait.....");

delay_ms(50);

lcd_gotoxy(0,0);

lcd_putsf("Reading Sensors ");

delay_ms(150);

lcd_gotoxy(0,0);

lcd_putsf("D_Sens    T_Sens");

delay_ms(100);

goto stage1;

};

while(2)

{

stage1:

x1=read_adc(0);

volt1=(float)(5)*(float)(x1)/(float)(255);

lcd_gotoxy(0,1);

ftoa(volt1,2,lcdbuffer);
```

```c
lcd_puts(lcdbuffer);

if (volt1>=3)

{

lcd_gotoxy(0,1);

lcd_putsf("Sun Detected   ");

delay_ms(100);

 goto stage2;

}

if (volt1<=1)

{

lcd_gotoxy(0,1);

lcd_putsf("Darkness        ");

delay_ms(100);

goto stop;

}

};
while(3)

{

stage2:
```

```c
x2=read_adc(1);

  volt2=(float)(5)*(float)(x2)/(float)(255);

  lcd_gotoxy(0,1);

  ftoa(volt2,2,lcdbuffer);

  lcd_puts(lcdbuffer);

  if (volt2<=1.5)

  {

  for (i=1;i<=10;i++)

  {

  PORTC.0=0x01;

  delay_ms(5);

  PORTC.0=0x00;

  delay_ms(5);

  PORTC.1=0x01;

  delay_ms(5);

  PORTC.1=0x00;

  delay_ms(5);

  PORTC.2=0x01;

  delay_ms(5);
```

```
        PORTC.2=0x00;

    delay_ms(5);

    PORTC.3=0x01;

    delay_ms(5);

    PORTC.3=0x00;

    delay_ms(5);

    goto stage1;

        }

        }

    };

    while(4)

    {
    stop:
    PORTC=0x00;
    lcd_gotoxy(0,1);
    lcd_putsf("Darkness      ");
    delay_ms(1000);
    goto start;
    };
}
```