DESIGN AND CONSTRUCTION OF SOLAR TRACKER USING MICROCONTROLLER AND SENSOR

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DEPARTMENT: ELECTRICAL AND COMPUTER ENGINEERING

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This thesis is submitted to department of electrical and computer engineering, Federal University of Technology Minna as partial fulfillment of the requirements for the award of the Bachelor of Electrical and computer Engineering (B.ENG)

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DEDICATION

This project is dedicated to God almighty and to my parents Engr. Matthew M. Gbayan and Mrs. Ruth I. Gbayan

DECLARATION

I Gbayan Bundega Martins declare that this project title "**design and construction of a solar tracker using microcontroller and sensors**" and the work content wholy or partly have never been submitted or published by anybody for degree to the best of my knowledge. All the references extracted were fully acknowledged.

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To all of you my friends you are not forgotten. I want so say a very big thankyou to you all for your moral and hard truth even in the toughest times.

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ABSTRACT

This is an improved solar tracking system from the former conventional one. The tracker is enhanced with a capacity to track the sun's position using its ray intensity at a particular time, using a solar tracking sensor and it calculate and display its intensity using an analogue temperature sensor. The solar tracker rotate the solar panel to a position of maximum solar radiation of the sun using a sensor which is been controlled by microcontroller. The microcontroller does this by calculating the point of maximum sun rays incident on the panel; using signal it get from the sensor.

TABLE OF CONTENT

CHAPTER ONE

CHAPTER TWO

LIST OF FIGURE

LIST OF TABLES

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The sun is the largest source of heat and light in the whole universe. It provides almost all the light and heat that we see or feel on the earth. The energy produced by the sun is called solar energy and it is electromagnetic in nature. The earth revolves around the sun constantly in every 24 hours from east to west producing constant solar radiation of 1353W/m^2, but because of the elliptical nature of the earth and change in season, the solar radiation varies between 1398W/m^2 in January 3 and about 1308W/m^2 in July annually[1]. Solar energy can be converted to heat for generation of electricity or by organisms for photosynthesis.

Solar energy is a very rich and clean source of energy with no emission of carbon (IV) oxide (CO_2). It has the capacity to produce the present and future need for electricity consumption; for instance, with only one percent of Nigerian land area of 923,773Km^2 it is possible to generate 1850×103GWh of solar electricity per year, this is over hundred times the current grid electricity consumption level in the country [2]. This can be achieved at relatively low and stable cost.

Since the position of the sun changes with time of the day, an intelligent system needed to be designed to be able to track the maximum radiation by the sun at different time intervals.

This project makes use of an intelligent and flexible solar tracking system which is software-driven to implement this objective.

1.2 MOTIVATION FOR THE PROJECT.

The motivation for this project came from the fact that we are leaving in the world at the time when there is shortage in power supply, and the conversion sources present are hazardous to the environment.

Energy is needed for every sphere of human endeavour, for instance we need energy to carry out our domestic and industrial processes. In rural areas the traditional source of energy is principally firewood and agricultural residue and this placed a great danger on the forest resources and increased global warming from the burning of incombustible carbon (CO).

Increase in the world human population have also placed high threat on the worlds' conventional energy sources, but with the sun, which is a renewable source of energy and have possibility of living for the next billion years with almost zero environmental pollution, the worlds' energy needs can be met.

With relatively simple devices and maintenance requirements, Zero environment pollution and Long life with little or no degradation in performance of the devices will solve the problem of the world energy crisis.

1.3 AIM/OBJECTIVES

The following are the aims and objectives for this project.

1) To produce a solar tracker which will track the maximum radiation from the sun by calculating the position of maximum sun intensity and rotating the panel in the direction.
2) To serve clean offgrid electrical power.

3) To improve on previous static solar panels

4) To increase the power production

5) To produce an environmentally friendly power system

6) To produce a relatively cost effective and efficient solar tracker.

7) To produce a solar tracker that will provide information for other field of sciences such as meterology.

1.4 METHODOLOGY

The system is designed to track the suns position all through the day, its position at a particular time of the day is controlled by a microcontroller using the results it get from calculating the level of the sun intensity at a particular point in time after which triggers a stepper motor to provide the précised position of panel.

The solar tracker is build with the following components system namely,

1) Power supply
2) AT89C52 microcontroller
3) Regulator
4) 555 timer and
5) Tracking mechanical assembly.

The tracking system is divided into the following units

1) Driving unit
2) Microcontroller unit
3) Display unit and

4) Timing unit
5) Power unit
6) Keypad unit
7) Transceiver unit
8) Sensing unit
9) Analogue to digital converter unit and
10) Personal computer unit

1.5 SCOPE OF PROJECT

The project work is to design and construct an automatic multifunctional solar tracking system using a micro-controller and sensors. The solar tracker system will rotate the position of the solar panel after calculating sun rays intensity on the panel.

The tracking system will also measure the temperature of the day and display it, as well as the state of the tracker at a all times. It will also have an interface between a personal computer where it can be controlled remotelly.

1.6 PROJECT ORGANISATION

The project is divided into five parts namely

Chapter one consist of the basic overview, the motivation, aims and objectives of the project and the methodology of the project.

Chapter two contains the literature review/theoretical background.

Chapter three contains the project design and implementation.

Chapter four is the test, result and discussion.

Chapters five consist of my recommendations and conclusion.

1.7 SOURCE OF MATERIALS

Materials used for this project where gotten in Minna, Niger State.

1.8 LIMITATIONS

During the course of this project I encountered the following difficulties.

- I had difficulty in sourcing for my materials used; I searched shop to shop for the materials for my project.
- I also had financial challenges during the course of my research on the internet, typing, and printing the project work.
- Good source of electricity also was a very big challenge I had; to ensure that this worked is type-set and submitted on time.

CHAPTER TWO

2.1.0 LITERATURE REVIEW

Humans have harnessed the power of the sun for millennia. In the fifth century B.C., the Greeks took advantage of passive solar energy by designing their homes to capture the sun's heat during the winter. Later, the Romans improved on solar architecture by covering south-facing windows with clear materials such as mica or glass, preventing the escape of solar heat captured during the day.

In the 1760s, Horace de Saussure built an insulated rectangular box with a glass cover that became the prototype for solar collectors used to heat water. The first commercial solar water heaters were sold in the U.S. in the late 1890's, and such devices continue to be used for pool and other water heating [3].

In the late 19th century, inventors and entrepreneurs in Europe and the U.S. developed solar energy technology that would form the basis of modern designs. Among the best known of these inventors are August Mouchet and William Adams. Mouchet constructed the first solar-powered steam engine. William Adams used mirrors and the sun to power a steam engine, a technology now used in solar power towers. He also discovered that the element selenium produces electricity when exposed to light.

The beginning of the 20th century witnessed increased interest into light energy; in 1921 Albert Einstein was awarded the Nobel Prize for his work in physics for his research on the photoelectric effect a phenomenon 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 [3].

In the 1970s, advances in solar cell design brought prices down and led to their use in domestic and industrial applications. PV cells began to power lighthouses, railroad crossings and off shore gas and oil rigs

In the last 20 years, solar energy has made further application in roads and now is used extensively in off-grid and remote power applications such as data monitoring and communications, well pumping and rural power supply, and in small-scale applications such as calculators and wristwatches. But solar power has not yet achieved its potential to become a major contributor to world electrical grid.

2.1.1 RECENT WORK

Marliyani Binti Omar in May 2009 worked on a low cost solar tracker. In the work a photovoltaic was used to convert light into electrical power using an inexpensive solar tracker. In order to maximize power output, the solar tracker was design with a motor such that the solar panel will move toward the position of sun. To control the solar panel so that it will always face the sun, the circuit had a timer that controlled the tracker movement. The timer indicated the time to move solar panel in 12 hours at every one hour interval controlled by a micro-controller. The solar tracker was design as an active tracker. [4]

Solar energy is rapidly gaining very great importance. As a means to expand solar renewable energy resources a solar tracker needed to be designed to return to its original position at the end of the day, that is go back from west to east. As such, it was vital that those in engineering fields understood the technologies associated with this area. A solar tracking system project in 2009 was designed and construction independently by Charles Asenokhai Otono and Chuwkwu Madujibe Collins.

Charles used microcontroller based solar tracking system. The solar tracker allowed more energy to be produced because the solar panel is able to remain aligned to the sun [5] and Collins design used a comparator IC and light dependent resistor (LDR) sensor. They designed and positioned two LDR sensors realize the single axis sunlight. [6]

In 2010 Engineer Joshua Abolarinwa Made research on a micro-controller based solar tracking system as a means to sustainable solar power generation and utilization. The tracking system was designed and developed using a programmable microcontroller as the main system unit and a timer, together with other units such as a driver unit, power unit and driving unit. By tracking the suns angle of incidence, the solar rays on the solar panels was improved. With the incorporation of automatic reset and restart mechanism in the tracker. [7]

2.2.0 THEORETICAL BACKGROUND

This section contains the basic theoretical information on the main subsystems of the project. Specifically, it discusses the power unit, solar sensor, software, light sensor, micro-controller, filtration, operational amplifier comparator, voltage regulator, transistor, drive types and DC motor theory in order to provide a better understanding as to how they relate to the solar tracker.

2.2.1 SOLAR SENSOR

This is a device which detects and measures a physical property. The sensor used for this project accepts solar ray signals and triggers the motor to move the mounting system so that the solar panels will always face the sun at its maximum angle of incidence. The light tracking circuit used provides an electrical driving impulse to the motor which is proportional to the rotational misalignment of the panels to the light source.

2.2.2 SOFTWARE

Software is a programme and other operating information used by a computer. For this project work C language was used to write the codes which operate the microcontroller.

2.2.3 MOTOR

This is a machine, especially powered by electricity or internal combustion, which supplies moving power for other devices.

For the purpose of my project a stepper motor was selected because of the precision it offers in positioning applications such as tracking systems. The motor specifically used in the project was a 5 volt, unipolar motor.

TYPES OF MOTOR DRIVE

I. DC motor drive

II. Induction motor drive

III. Synchronous motor drive

A. THEORY OF STEPPER MOTOR

A stepper motor can be viewed as a synchronous motor with the number of poles (on both rotor and stator) increased. Figures (1) show a schematic diagram of stepper motor. Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor). Modern steppers are of hybrid design, having both permanent magnets and soft iron cores.

To achieve full rated torque, the coils in a stepper motor must reach their full rated current during each step. Winding inductance and reverse EMF generated by a moving rotor tend to resist changes in drive current, so that as the motor speeds up, less and less time is spent at full current thus reducing motor torque.

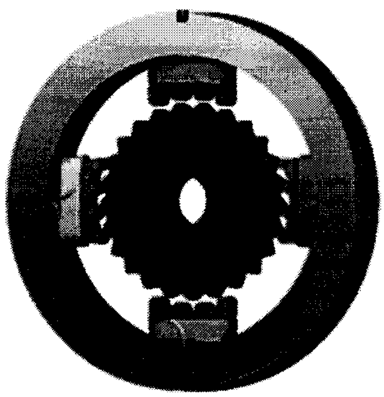
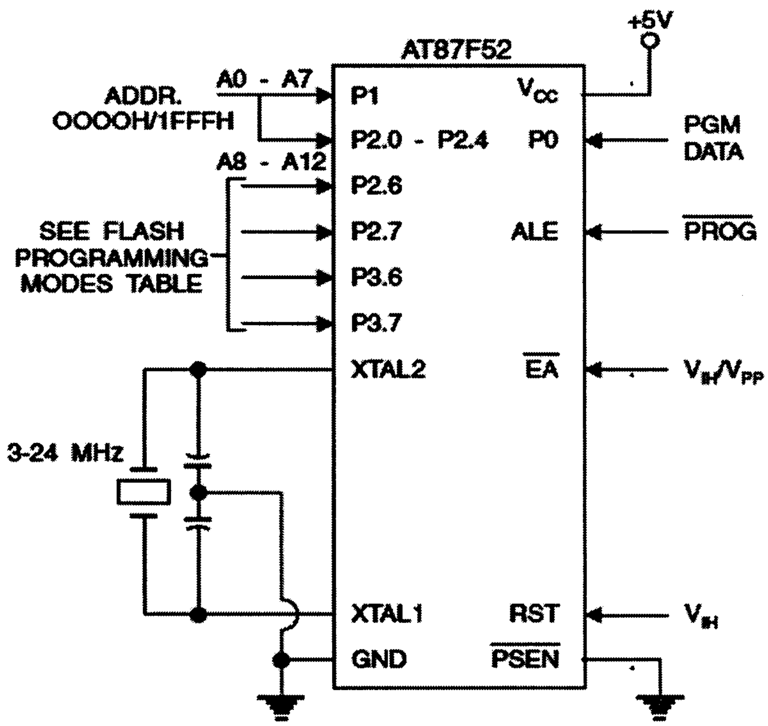


Figure:2. 1 Stepper motor

2.2.4 AT89S52 MICRO-CONTROLLER

A microcontroller is the heart of the solar tracking system. It is a device which regulates the activities of the system with the help of written software. The microcontroller selected for this project had to be able to convert the analog photocell voltage into digital values. AT89S52 was selected which is a low-power, high-performance CMOS 8-bit microcontroller with 8 kilobytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin-out. The on-chip Flash allows the program memory to be reprogrammed in the system or by a conventional nonvolatile memory program. Figure (2) show a diagram of an AT89S52 micro-controller.



Figgure: 2.2 AT89S25

2.2.5 LIGHT SENSOR THEORY

One of the key modules in this project is the sensor. Because the sensor tracks the solar light source's orientation, selecting the right tracking sensor is very important. The simplest optical sensor is a photo-resistor which may be a cadmium sulfide (CdS) type or a gallium arsenide (GaAs) type; for this work the sun tracker used is a cadmium sulfide (CdS) photocell for light sensing, because of its inexpensive and less complex. The CdS photocell is a passive component whose resistance is inversely proportional to the amount of light intensity directed toward it. Figure (3) CdS sensors.

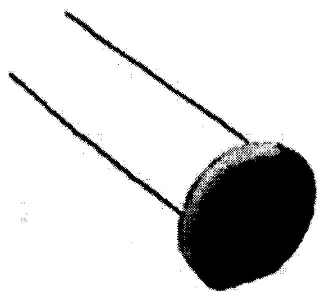


Figure:2.3 cadmium sulfide (CdS) stereogram

2.2.7 VOLTAGE REGULATOR

This is an Integrated Circuit IC which helps to keep the terminal voltage of the dc supply constant even when the input voltage to it varies. The voltage regulators are of fixed and adjustable output and the fixed output type are either positive or negative. There are various types of regulator circuit such as zener diode shunt regulator, transistor series voltage regulator, switching regulators and so on. All the above mentioned circuit is made from discrete components. The type of voltage regulator used in this project is the integrated circuit (IC) voltage regulator for D.C voltages. This IC has more improved performance as compared with the other discrete component mentioned. They have unique built-in features such as current limiting self-protection against over temperature.

2.2.8 TRANSISTOR

The transistors used in this circuits are for, amplification of signal and as a switch (on/off) in various circuits. Switching is very important in this design and other electronic devices. A common bipolar transistor is used in this design for the switching operation and it works as an electronic switch. Power transistors are used in this applications ranging from a few to several hundred kilowatts and switching frequencies up to about 10 kHz. Power transistors are used in power conversion applications. The power transistor is turned on by supplying sufficient base current, and this base drive has to be maintained throughout its conduction period. It is turned off by removing the base drive and making the base voltage slightly negative (within – VBE(max)). The saturation voltage of the device is normally 0.5 to 2.5 V and it increases as the current increases. Hence, the on-state losses increase more than proportionately with current. The transistor off-state losses are much lower than the on-state losses because the leakage current of the device is in the order of a few milli-amperes.

2.2.9 POWER UNIT

The power unit supply the power required by various circuits components within the system in DC form. For the purpose of this project a battery was used to power the circuit. Figure (6) show the power unit.

To make the light tracking model self sufficient, a 6 volt input battery was connected to regulator which help to maintained the voltage at 5volt which is used to drive the electronic components.

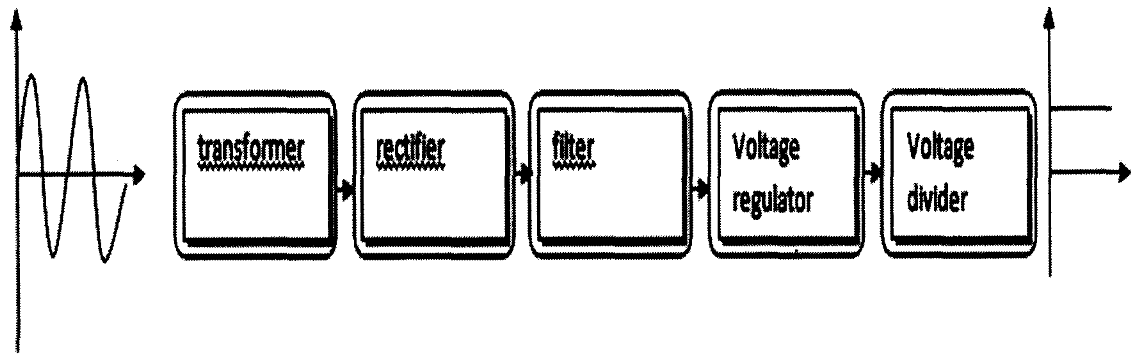


Figure:2.4 Block diagram of power unit

2.2.10 DRIVE

A drive is an electromechanical device that operates by controlling the speed of the equipment by providing its propelling force.

TYPE OF TRACKER DRIVES

A. ACTIVE TRACKERS

Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. In order to control and manage the movement of these tracker structures special slewing drives are used.

This project uses an active tracker. The light intensity measured from the sun determines where the solar modules should be pointing. Light sensors are positioned on the tracker at the shaped holders. If the sun is not facing the tracker directly there will be a difference in light intensity on one light sensor compared to another and this difference can be used to determine in which direction the tracker has to tilt in order to be facing the sun[8].

B. PASSIVE TRACKER

Passive trackers use a low boiling point compressed gas fluid that is driven to one side or the other (by solar heat creating gas pressure) to cause the tracker to move in response to an imbalance. It is a non-precision tracker which is unsuitable for certain types of concentrating photovoltaic collectors but works well for common PV panel types.

C. CHRONOLOGICAL TRACKER

A chronological tracker counteracts the Earth's rotation by turning at an equal rate as the earth, but in the opposite direction. Actually the rates are not quite equal, because as the earth goes around the sun, the position of the sun changes with respect to the earth by 360° every year or 365.24 days. A chronological tracker is a very simple yet potentially a very accurate solar tracker.

2.3.0 A SOLAR TRACKER

A solar tracker is a device for orienting a solar photovoltaic panel or concentrating solar reflector toward the sun. Concentrators, used in solar cell applications, require a high degree of accuracy to ensure that the concentrated sunlight is directed precisely to the powered device. Non-concentrating applications require less accuracy. A tracker is necessary, to improve substantially the amount of power produced by the system by enhancing morning and afternoon performance. Strong afternoon performance is particularly desirable for grid-tied photovoltaic systems, as production at this time will match the peak demand time for summer season.

TYPES OF SOLAR TRACKER

There are many different types of solar tracker which can be grouped into single axis and double axis models.

A. SINGLE AXIS SOLAR TRACKER

Single axis trackers have one degree of freedom that acts as an axis of rotation. The axis of rotation of single axis trackers is typically aligned along a true North meridian. It is possible to align them in any cardinal direction with advanced tracking algorithms.

There are several common implementations of single axis trackers. These include Horizontal Single Axis Trackers, Vertical Single Axis Trackers, and Tilted Single Axis Trackers. The orientation of the module with respect to the tracker axis is important when modeling performance.

I. HORIZONTAL SINGLE AXIS TRACKER (HSAT)

The axis of rotation for Horizontal Single Axis Tracker is horizontal with respect to the ground. The posts at either end of the axis of rotation of a Horizontal Single Axis Tracker can be shared between trackers.

II. VERTICAL SINGLE AXIS TRACKER (VSAT)

The axis of rotation for Vertical Single Axis Trackers is vertical with respect to the ground. These trackers rotate from East to West over the course of the day. Such trackers are more effective at high latitudes than are horizontal axis trackers.

III. TILTED SINGLE AXIS TRACKER (TSAT)

All trackers with axes of rotation between horizontal and vertical are considered Tilted Single Axis Trackers. Tracker tilt angles are often limited to reduce the wind profile and decrease the elevated end's height off the ground.

B. DOUBLE AXIS SOLAR TRACKER

Double axis solar trackers have both a horizontal and a vertical axle and so can track the Sun's apparent motion exactly at any time because it have two degrees of freedom that act as axes of rotation. These axes are typically normal to one another.

I. AZIMUTH-ALTITUDE DUAL AXIS TRACKER (AADAT)

An Azimuth – Altitude Dual Axis Tracker has its primary axis vertical to the ground. The secondary axis is then typically normal to the primary axis.

II. TIP-TILT DUAL AXIS TRACKER(TTDAT)

A Tip-Tilt Dual Axis tracker has its primary axis horizontal to the ground and the secondary typically at normal to the primary axis. The axis of rotation of tip-tilt dual axis tracker is typically alligned either to along a true north meridian or east west line of latitude.

CHAPTER THREE

3.0 DESIGN AND CONSTRUCTION

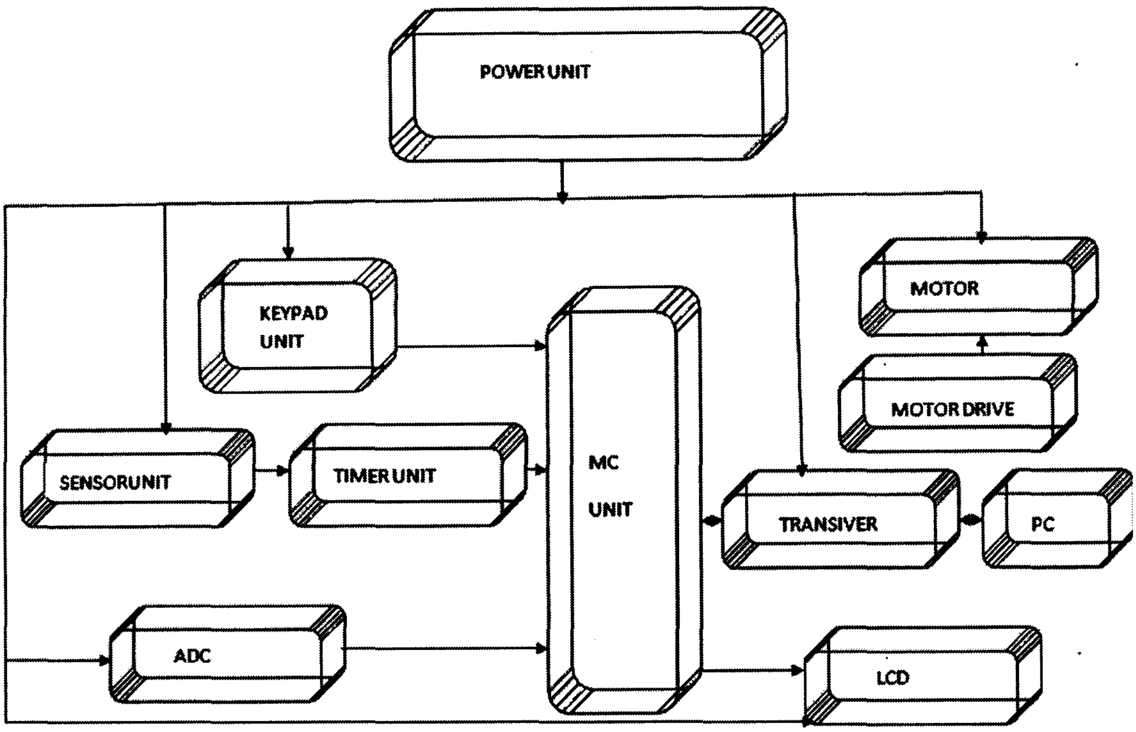


Fig 3.1: Solar tracker block diagram

3.1.0 POWER UNIT

The objective of power unit is to power the entire circuit of the solar tracking system. The power unit is a stand alone unit which is capable of continously coverting solar energy into electrical energy. For the purpose of this project a 6V stand alone power supply unit is used to consantly supply power into the circuit.

3.2.0 MICROCONTROLLER UNIT

A mirocontroller is a self contained system with the processor, memory and peripherals and used as an embeded system [9]. It provides real time response to events in the embeded systems they control. When certain events occur, an interrupt system can be signalled to the processor to suspend processing the current instruction sequence and to begin an interrupt routine. To logically control the microcontroller, programs are fit in the available on-chip memory.

The microcontroller to be used for this project must be low powered, high performance, 8 bit microcomputer with 8 kilobytes of flash programmable and erasable nonvolatile memory technology. And it must also be readily availabe. Other features which the microprocessor must support include:

- It must be able to handle the task at hand efficiently and it must be cost effective.
- It must support maximum operating speed of the motor unit.
- It must have sufficient I/O pins to support the interfaces required by the tracker.

One of the must widely used and readily availabe microcontrollers with all the features listed above and has the capacity to meet the needs of this project is the AT89C52. The AT89C52 is compatible to industrial standard of 80C51 and 80C52 instruction set and pin-out. The on-chip flash allows the microprocessor to be reprogrammed.

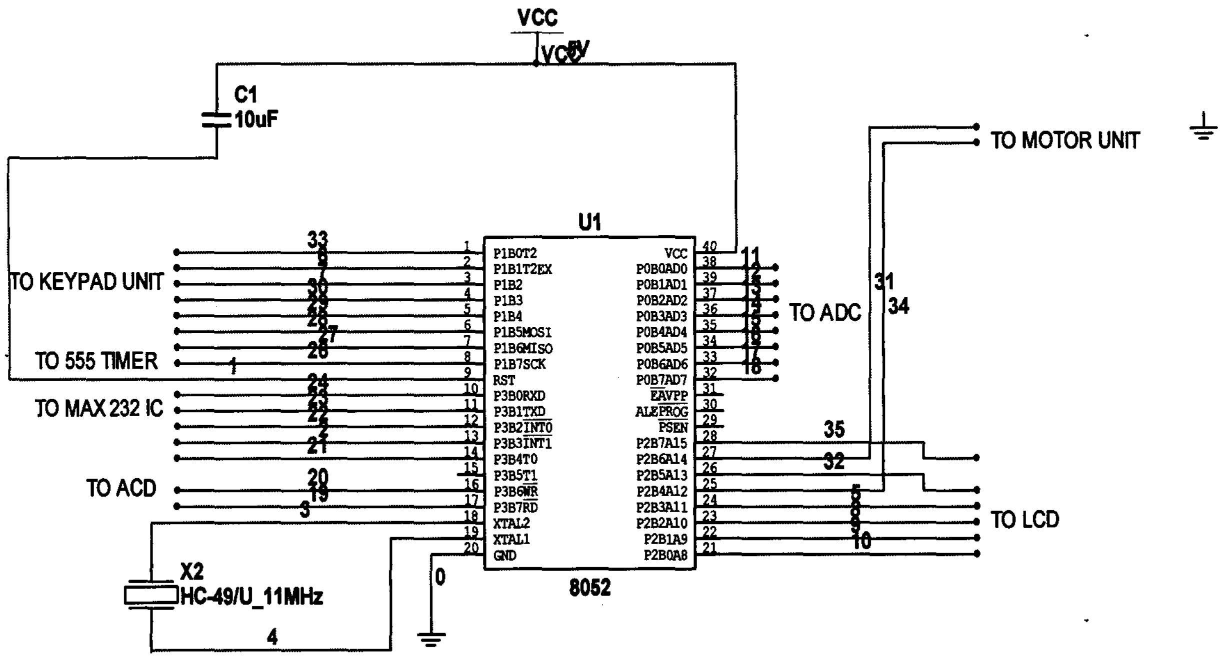


Fig.3.2: schematic circuit diagram of microcontroller unit

3.2.1 FEATURES OF 89C52 MICROCONTROLLER

- ❖ Compatible with MCS-51™ Products
- ❖ 8K Bytes of In-System Reprogrammable Flash Memory
- ❖ Endurance: 1,000 Write/Erase Cycles
- ❖ Fully Static Operation: 0 Hz to 24 MHz
- ❖ Three-level Program Memory Lock
- ❖ 256 x 8-bit Internal RAM
- ❖ 32 Programmable I/O Lines
- ❖ Three 16-bit Timer/Counters
- ❖ Eight Interrupt Sources

- ❖ Programmable Serial Channel
- ❖ Low-power idle and Power-down Modes[10]

3.3.0 SENSING UNIT

The sensing unit consists of two independent units, the solar sensing unit and the temperature sensing unit

3.3.1 SOLAR SENSING UNIT

The solar sensing unit has a light dependent resistor (LDR) as it major component. It is connected in series to a 10kΩ variable resistor. The variable resistor is used to tune the level of darkness required to be sensed before the LDR trigger the timing unit to produce the desired effect. The voltage output of the LDR can be calculated using the equation below.

$$Vout = \frac{VR1}{VR1 + R1} \times Vcc$$

The LDR is an important component in the circuit because it turns on and off the timer automatically according to the level of light intensity.

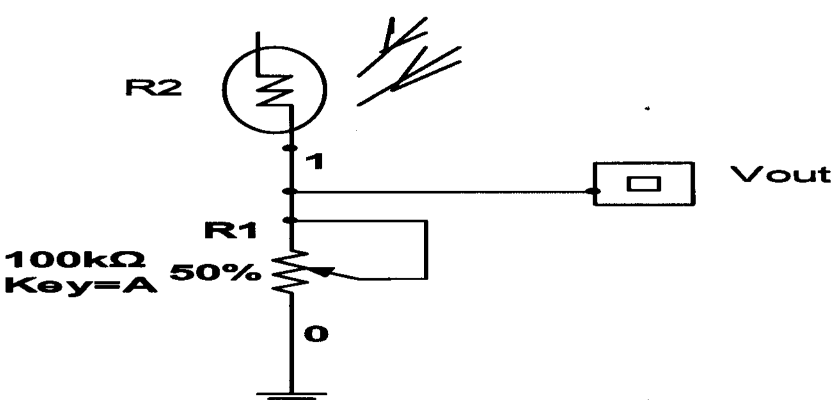


Fig.3.3: schematic diagram of solar sensing unit

3.3.2 TEMPERATURE SENSING UNIT

The temperaure sensing unit has LM 35 as its major component. LM 35 is a series precision integrated circuit temperature sensor with accuracy of ±1/4^{0}C at room temperature and ±3/4^{0}C over a full -55 to +150^{0}C temperature range and its output is linearly proportional to the Celsius temperature [11]. LM 35 was chosen as the temperature sensor because of its low output impedance of 0.1Ω for 1mA load; linear output and precise inherent calibration make interfacing to read-out and control circuit easily.

Other features that make LM 35 suitable for the project include:

- Linear +10.0mV/^{0}C sclae factor
- Rated range of -55 to 150^{0}C range
- Suitable for remote application
- Low cost
- Operate from 4 to 30 volts
- Less than 60μA current drain
- Low self heating, 0.08^{0}C in still air[12]

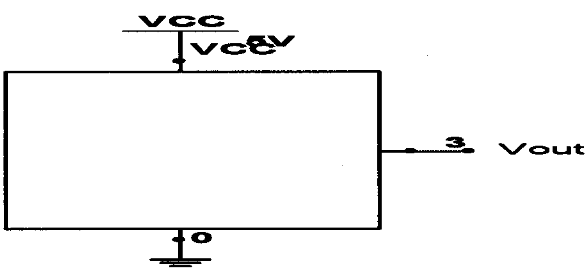


Fig.3.4: basic centigrade view temperature

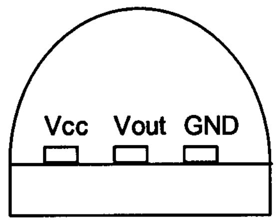


Fig 3.5: bottom view of LM 35

3.4.0 TIMER UNIT

The timing unit consists of a 555 timer, connected to a resistor and capacitor such that it forms a monostable mode.

The 555 timer is the most important component of this unit. It is used for pulse generation. The output of the 555 timer is incorporated to the microcontroller where the basis for the oscillator driving the charge pumps provides the programming overvoltage.

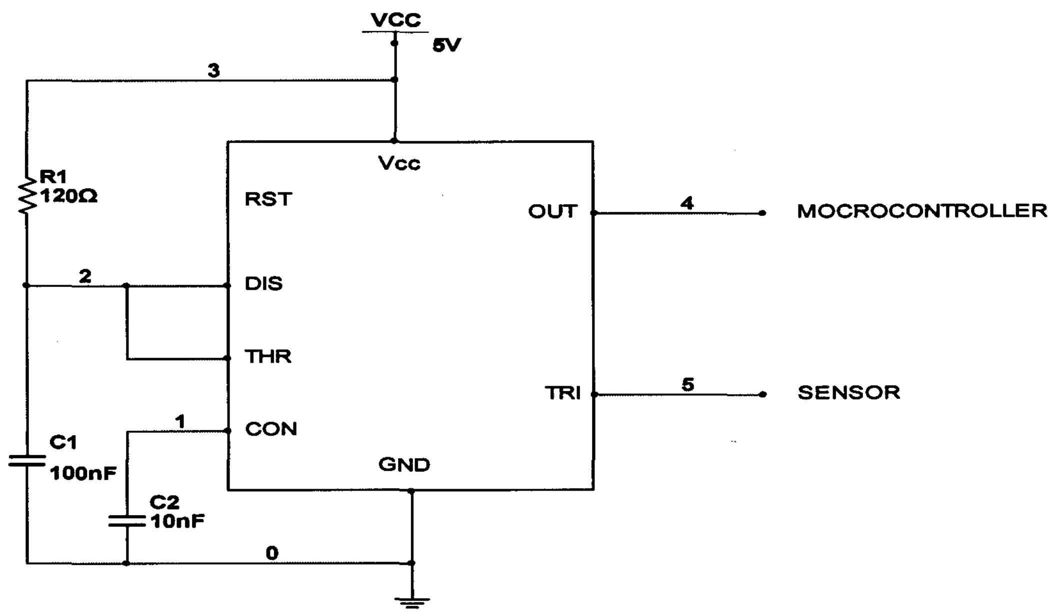


Fig.3.6: Schematic of a 555 timer in monostable

3.4.1 MONOSTABLE MODE

In the monostable mode, the 555timer acts as a one-short pulse generator. The pulse begins when the 555 timer received signal at the trigger input falls below 1/3 of the voltage supply. The width of the output pulse is determined by the time constant of an RC network, which consists of a capacitor(C) and a resistor(R).

The output pulse end when the charge on the capacitor equal 2/3 of the supply voltage. The output pulse width can be lengthend or shortend to meet the needs and specific application by adjusting the value of the resistor and capacitor. The output pulse width time (t) is the time it takes to charge C to 2/3 of the supply voltage. t is given by

$$t=RC\ln(3) \approx 1.1RC$$

R=resistance, C=capacitor

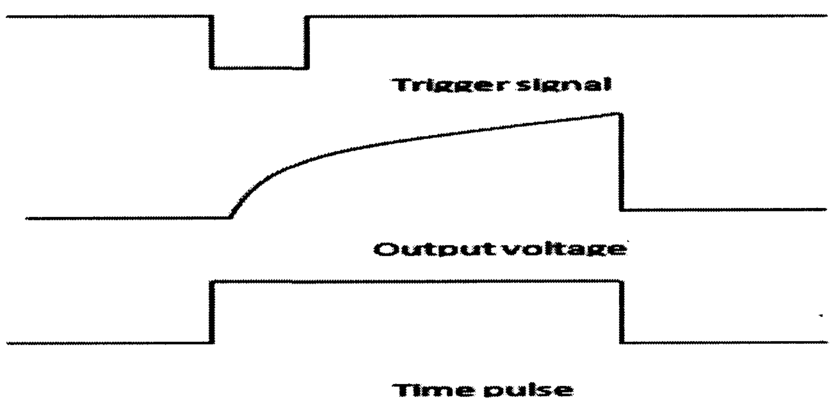


Fig. 3.7: Relationship between the trigger signal, the voltage on the capacitor and the pulse width in monostable mode

3.5.0 ANALOGUE TO DIGITAL CONVERTER (ADC)

An analogue to digital converter (ADC) is a device which converts a continous quantity to a discrete time digital time representation. An analogue to digital converter (ADC) may also provide an isolated measurement.

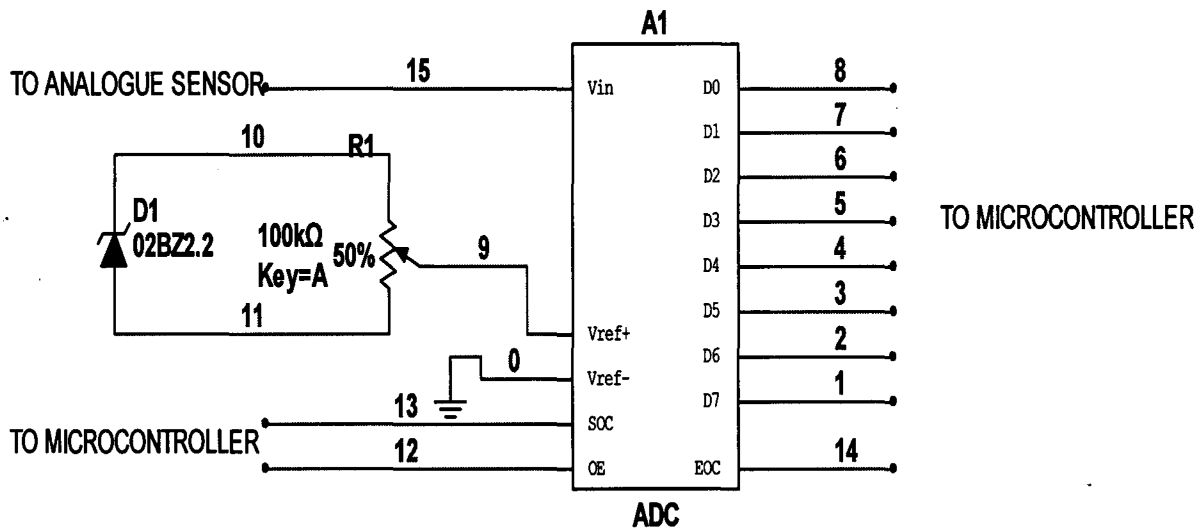


Fig.3.8: schematic circuit diagram of ADC unit

3.5.1 ADC SELECTION

In seleting an ADC for this project very important factors were taken into consideration namely:

I. Resolution

II. Accuracy

III. Gain and offset error

IV. Gain and offset drift

V. Conversion time

VI. Aparture and conversion time

VII. Code width

VIII. Low power requirement

To this ends ADC0804 was selected for the project because it meets the above factors as required for this project.

The ADC0804 is a family of ADC080X. ADC080X family is an 8 bit successive approximation A/D converter which uses a modified potentiometer ladder and is designed to operate with 8080A bus via three state outputs. The A/D is linked to the microcontroller via; these converters appear to the processor as memory location hence no interface logic is required between the processor and the ADC [13].

A differential analogue voltage is experienced at the input which has a common-mode-rejection and permit offsetting the analogue zero-input-voltage value. In addition the reference input can be adjusted to allow encoding any smaller analogue voltage span to the full 8bit of resolution.

3.5.2 FEATURES OF ADC0804

- 80C48 and 80C80/85 bus compatible-no interface logic required
- Conversion time..< 100μs
- Easy interface to most microprocssors
- Will operate in a "stand alone " mode

- Differential analogue voltage inputs
- Working with band gap voltage references
- TTL compatable input and outputs
- On-chip clock generator
- Analogue voltage input range

(single +5V supply.............. 0V to 5V)

- No zero adjust required
- 80C48 and 80C80/85 bus compatible-no interfacing logic required.(ADC datasheet)

3.6.0 TRANSCEIVER UNIT

The logic level of microcontroller is not compatible with the COM port of the computer interface; hence for the microcontroller to effectively communicate with the computer, a logic level converter is required. To solve this problem, the MAX232 IC is used.

MAX 232 is an integrated circuit(IC) that converts serial port to signals suitable for transistor-transistor logic (TTL) compatible for logic circuits. The MAX 232 is a dual driver and receiver and typically converts the receiver, transmiter, circuit and receivers signals.

MAX232 is a standard for transferring information in serial format. The information is sent in small packets of data called frames. A data frame consist of a start bit, the actual data word, an optional parity bit and ends with one or two stop bits. The data word can be 7 or 8 bit long. This is as illustrated in the figure below.

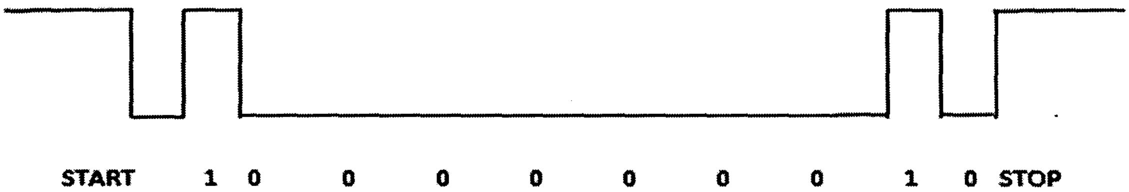


Fig.3.9: Bit pattern for transmitting character 'A'

The drivers provide RS-232 voltage level approximatly ±7.5V from a single +5V suppy through on chip charge pumps and external capacitors. When the MAX 232 IC receive a TTL level a logic zero is represented by positive voltage between +3V DC and +15V DC while logic one is represented by a negative voltage between -3V DC and -15V DC [14]. The circuit diagram of the MAX232 is as shown below. For proper operation, it uses four external capacitors.

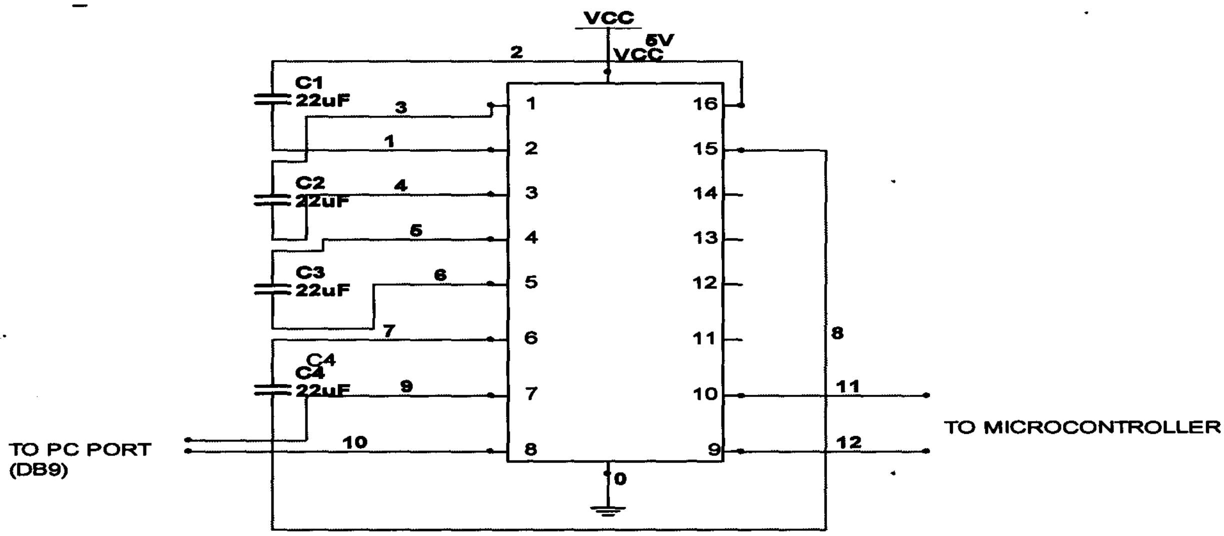


Figure 3.10: schematic diagram of transceiver unit

The standard also uses the DB9 connector in connecting with the COM port of the computer system. The receive (pin 8) and transmit (pin9) pins of the MAX232 are connected respectively to the receive data pin and the transmit data pin of the connector. Pin 9 and pin 10 of the MAX232 are also connected respectively to the receive (pin 10) and transmit (pin 11) pins of the microcontroller. The serial port contains a number of handshaking lines that are used to indicate the willingness of the receiver to receive data and the sender to send data. But this device uses three out of the handshaking lines in communicating with the serial port. These lines are; data receive line, data transmit line and signal ground. The DB9 connector is as shown in figure 3.14 below.

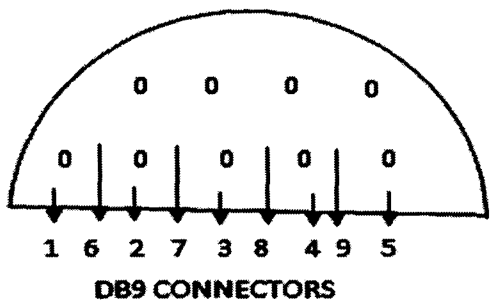


Figure 3.11: DB9 connector

Below shows the summary of the function of individual pin:

Table 3.1 Pin function of DB 9 connector

PIN	FUNCTION
1	Data carrier detect
2	Receiver data
3	Transmit data
4	Data terminal ready
5	signal ground
6	Data set ready
7	Request to send
8	Clear send
9	Ring indicator

To control the device through the computer interface, software was written in visual basic language to communicate with the device through the COM port of the computer. The interface allows the following command;

- Start tracking
- Stop tracking
- Clockwise rotation
- Anticlockwise rotation

3.7.0 DISPLAY UNIT

This is an electronic visual display unit. It comprises of a liquid crystal display (LCD). An LCD consists of two pieces of glass with a layer of liquid in between which will drive in specific areas when a voltage signal is applied. An LCD is very crucial in this project because it provides a human interface. It provides information on the status of the tracker.

To select the LCD to be used for this project cost, power requirements and availability where considered as very important factors. The LCD driver design is enhance to

- Mix analogue-digital
- Very large scale of integrated ASIC design ususally structured through out the following:

- Project proposal: analysis of system level requirements based on the application

- ➢ Architecture implementation: block level design of both analogue and digital parts. Analogue circuit design and digtal register-transfer- level description and coding.
- ➢ Analogue and digital place and route and time verification

To satisfy the needs of this project HD44780U LCD was selected since it meet out requirements needs for the project.

3.7.1 DISCRIPTION OF HD4478U LCD

The HD44780U dot-matrix liquid crystal display controller displays alphanumerics, Japanese kana characters, and symbols. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4 or 8-bit microprocessor. Since all the functions such as display RAM, character generator, and liquid crystal driver, required for driving a dot-matrix liquid crystal display are internally provided on one chip, a minimal system can be interfaced with this controller.

A single HD44780U can display up to one 8-character line or two 8-character lines.

The HD44780U character generator ROM is extended to generate 208 5×8 dot character fonts and 32 5 ×10 dot character fonts for a total of 240 different character fonts. The low power supply (2.7V to 5.5V) of the HD44780U is suitable for any portable battery-driven product requiring low power dissipation.

3.7.2 FEATURES HD4478U LCD

- ❖ 5×8 and 5×10 dot matrix dot matrix possible.
- ❖ Low power operation support: 2.7 to 5.5V

- Wide range of liduid crystal display driver power: 3.0 to 11V
- Liquid crystal wave form:A (one line AC waveform)
- Correspondent to high speed MPU interface: 2MHz (when Vcc=5V)
- 4 bit or 8bit MPU interface enabled
- 80×8 bit display RAM (8 character MAX).

  208 character font (5×8 dot)

  32 character font (5×10 dot)
- 64×8 bit character generator RAM

  8 character font (5×8 dots)

  4 charater font (5×10 dots)
- 16 common × 40 segment liquid crystal display driver
- Programmable duty cycle

  1/ 8 for line 5×8 dot with cursor

  1/11 for one line 8×10 dot with cursor

  1/16 for one line of 5×8 dot with cursor
- Wide range of instruction functions:

Display clear, cursor home, display on/off, display character blink, cursor shift, display shift.

- ❖ PIN function compatibility with HD44780s
- ❖ Internal oscillator with external resistor
- ❖ Low power consumption
- ❖ Automatic reset circuit that initialize the controller/driver after power on[15]

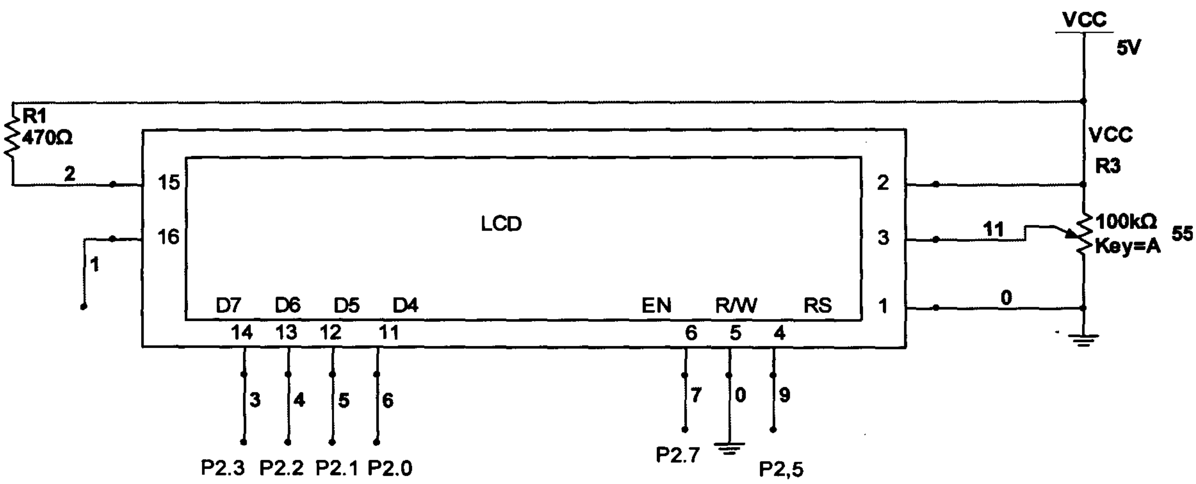


Figure 3.12: schematic diagram of display unit

Table 3.2: Pin description of HD4478 LCD

SIGNAL	NO. OF LINES	I/O	DEVICE INTERFACE	FUNCTION
RS	1	1	MPU	Selects register 0: Instruction register (for write) busy flag: address counter (for read) 1:Data register(for write and read)
R/W	1	1	MPU	Select read or write 0: Write 1: Read
EN	1	1	MPU	Start data read/write
DB4 to DB7	4	I/O	MPU	Four high order bidirectional tristate data bus pins. Used for data transfer and receive
COM1 TO COM16	16	0	LCD	Common signal that are not used to no-selection waveform COM9 to COM16 are non-selection waveforms at 1/8 duty factor and COM12 to COM
Vcc, GND	2	-	power supply	Vcc: 2.7 to 5.5V GND: 0V
Legend:	RS=reset COM=comport	R/W=read/write	EN=enable	I/O=input/output

3.8.0 MOTOR UNIT

To drive the DC motor, an H-bridge circuit was designed using four 2N3904 NPN transistors, two TIP31 NPN transistor and two TIP32 PNP transistors. One 2N3904 transistor and TIP31 transistor were connected as Darlington pair and another 2N3904 and TIP32 were directly coupled as complementary symmetry (i.e. NPN to PNP). This connection was made to get a high current gain enough to drive the motor at the output. For 2N3904 it has the following specification;

$I_{c(max)} = 200mA$

$V_{CE(sat)} = 0.3V$

$I_c = 50mA$

$I_B = 5.0mA$

$V_{BE(sat)} = 0.95V$

$h_{FE} = 60$

$I_B = \frac{Vbb - Vbe}{Rb}$

Hence $R_B = \frac{Vbb - Vbe}{IB}$

$R_B = \frac{5 - 0.95}{5e-3} = 810\Omega$

Therefore a commercial value of $1K\Omega$ was used to bias the transistor.

TIP31 has current gain of 50, since it was connected as a Darlington pair with 2N3904 with gain of 60; it gives a total gain of 3000. When the two input to H-bridge are low, the motor stop rotating, if both input are high, it breaks, if one is high and the other low, it rotates in one direction, and if the input are reversed, it rotates in the opposite direction. The circuit diagram is as shown in the figure below.

3.8.1 MOTOR SELECTION

Considering the operation of this device, a stepper motor is in best position to be used to rotate the panel for its high simplicity, no brushes or contacts are present, low cost, high reliability, high toque at low speed, and high accuracy of motion as compared to a bidirectional DC motor]. But all efforts to get a stepper motor proved abortive; hence a bidirectional DC motor was used. The H-bridge was designed to provide the required current to drive the motor.

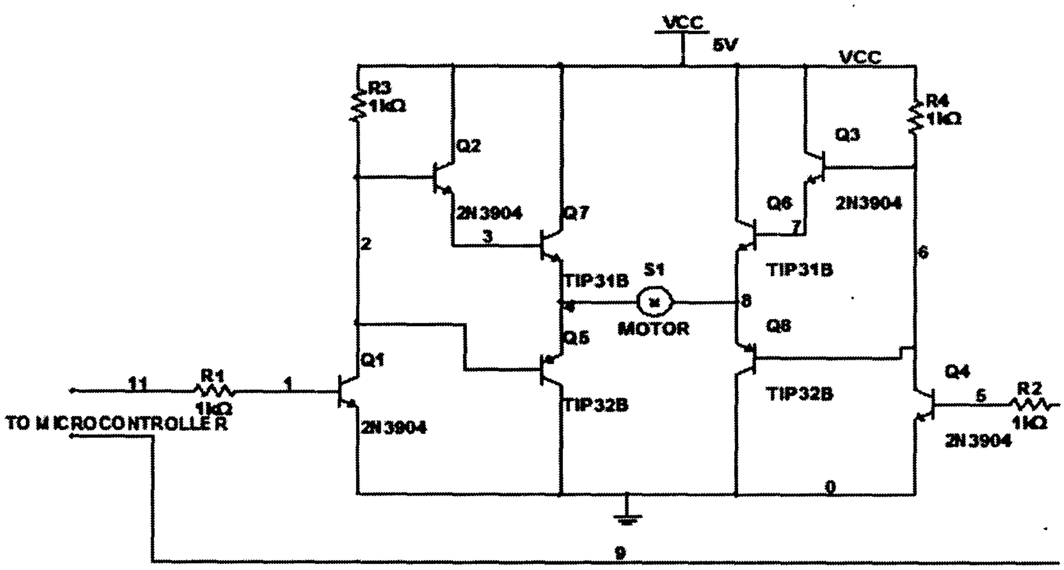


Figure 3.13: schematic diagram of motor unit

3.9.0 KEYPAD UNIT

This unit comprises of four different switches; the start switch to set the solar panel to start tracking, the stop switch to stop the solar panel from tracking the sun, the limit switch one determines if the panel has reached the extreme end at the east, the limit switch two determines if the solar panel has reached the extreme end at the west. The inputs to the microcontroller from the switches were all held high through a pull-up resistor making them normally high and active low.

3.9.1 CALCULATION OF PULL-UP RESISTORS

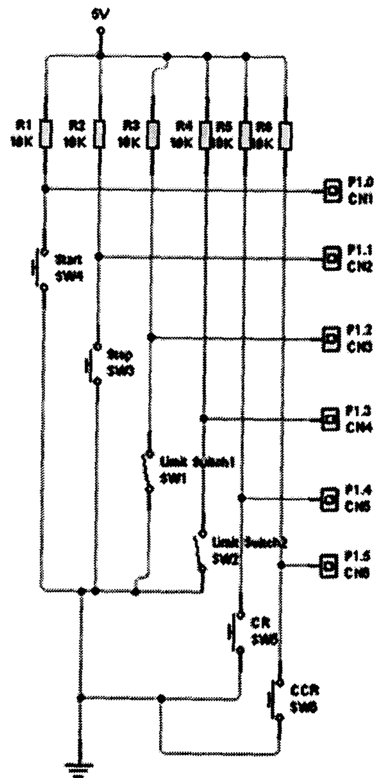


Figure 3.14: schematic diagram of keypad unit

Fig.3.14 shows the circuit diagram of the keypad unit. The circuit consists of two (2) push-to-on switches, Sw3 and Sw4 and two single pole single throw switch (SPST). Each switch is connected from the pins of microcontroller to the ground. Every microcontroller has ability to sink or source current. The type of microcontroller used in this design is AT89C52. From the datasheet [11] of AT89C52, port1, 2 and 3 can sink current of about 1.6mA. Therefore, by taking the sinking current to be 0.5mA, the pull-up resistors can be calculated.

From the fig.3.4, V_{cc} = IR,

Where V_{cc} = +5V, I = 0.5mA, R = pull-up resistor.

Therefore, $R = \frac{Vcc}{I} = \frac{5V}{0.5mA} = 10k\Omega$

3.9.2 PRINCIPLE OF OPERATION

The pins connected to the switches are held HIGH by the pull-up resistors. The I/O ports of the 8051 microcontroller can be both read and written to (bidirectional), therefore, if any of the switches, after being powered, is pressed, the concerned pin of the microcontroller will be pulled down to ground which serves as the input to the microcontroller. When microcontroller senses a signal from that pin, it will execute the instructions related to the switch pressed as directed by the software programming.

3.10.0 PC

The PC creates an interface between itself and the MAX 232. It provides remote control for the tracker and help if there is problem with the tracker

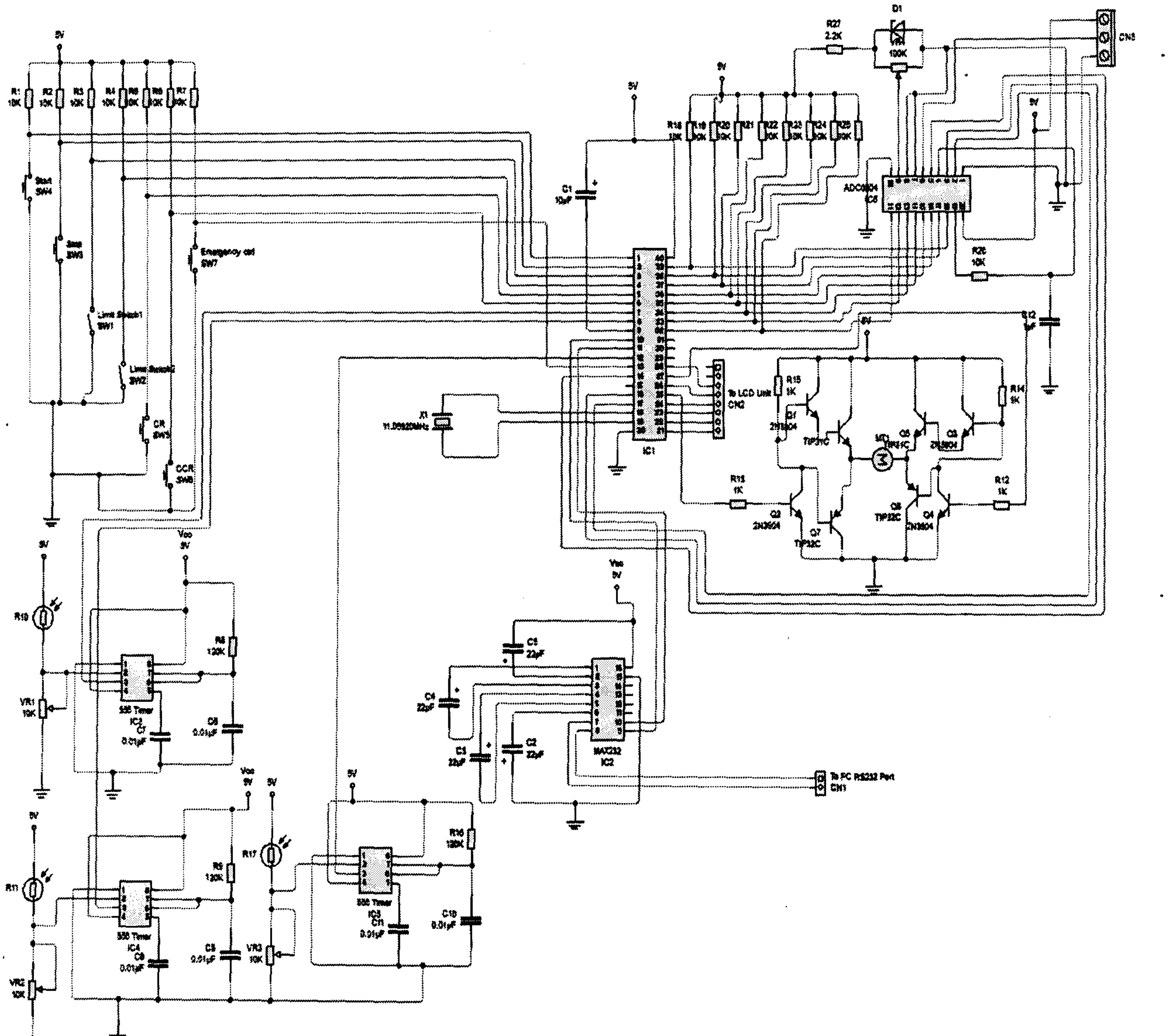


Fig 3.15 Automatic Solar Panel Controller Circuit Diagram

COMPLETE CIRCUIT DIAGRAM

CHAPTER FOUR

4.0 TESTS, RESULT AND DISCUSSION

4.1.0 TEST

The project testing was divided into two broad parts namely the hardware test and software test.

4.1.1 HARDWARE TEST

This has to do with checking if the components were well connected and that the required responses were gotten. To do this power was feed using a 6V battery through the Vcc of the circuit and the voltage was read for all the units. The result for the readings is shown in table 4.1.

During the test it was observed that pin 1.0 of the microcontroller where a pull-up resistor is connected read 0V instead of 5V. The problem was checked and it was.observed that current was not flowing through the 10Ω resistor, it was then thought that the resistor was faulty and it was replaced however the problem persisted and it was again checked, it was latter observed that the problem was from the push button connected to the resistor at the keypad unit and the button was replaced.

After the test to verify that all the IC sockets and all the other circuit components were well powered, the variable resistor connnected to the liquid crystal display (LCD) was tested to ensure that the LCD was responding effectively to it, and the LCD was then set.

The ICs were then fixed into their sockets and the pins where again tested to ensure that they were receiving the same 5V feed into the IC sockets.

Pin 2 of the 555 timer was then set to high by adjusting the variable resistor connected to it to a value above 2.0Ω so that pin 3 of 555 timer is normally low under light intensity. The light dependant resistors (LDR) were then tested and it was observed that when any of the LDR set to detect the point of highest sun light intensity senses it; pin 3 goes normally high to indicate the presence of darkness. Hence this is what the microcontroller will monitor to decide were to rotate the pannel to.

Pin 9 which is the Vref of the ADC was set to 1.28V so that the main analogue input voltage will be 2.56V. the input voltage to pin 6 of the ADC will range from 0-2.56V since it is an 8bit ADC the maximum digital output is 2^8 (256) and the LM 35 is calculated as 10mV/degree rise in temperatue.

4.1.2 SOFTWARE TEST

The code for the microcontroller was transferred into the microcontroller chip and inserted into its IC socket and tested. During the test the entire circuit was powered and the LCDs were tested to ensure that it responded to the microcontroller output. During the test it was observed that the read and write pin of the LCD was not well grounded and hence it could not read from the microcontroller. The problem was verified by properlly grounding the LCD.

The test was again carried out and the LCD showed initialization information and temperature of the day.

When the sensors are in darkness the LCD display information to indicate it is in idle mode and when it is not in idle mode pin 3 generate an interupt to the microcontroller to adjust the position of the pannel by triggering the motor.

4.2.0 RESULT

During the test the voltage readings were taken and tabluted as shown below.

Table 4.1: Result of test carried out during the project

COMPONET	INPUT VALUE	DESIGNED VALUE	READING
555 TIMER	6V	5V	4.95V
MICROCONTROLLER	6V	5V	4.95V
ADC	6V	5V	4.95V
MAX 232	6V	5V	4.95V
TRANSISTOR	6V	5V	4.95V

When the solar sensing LDRs are in darkness pin 3 become normally high and pin 2 goes normally low.

The temperature sensing unit also measured the temperture of the day.

The entire circuit component responded to both the hardware and software test effectively.

4.3.0 DISCUSSION OF RESULT

Testing and ensuring that the system work withing the required design is very essential. This will help to avoid malfunctionin of the circuit.

During the test accuracy was taken very important to ensure that the results gotten were not misleading. The IC suckets were tested to ensure that ≈5V was gotten. The sensing, motor, LCD, tranceiver, power, keypad, microcontroller, ADC, timer and PC units where tested and they all responded to the test well.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMENDATION

5.1.0 CONCLUSION

This project implement an economic, and multifunctional bidirectional solar tracking system which is capable of tracking maximum sun ray althrough the day.

The tracker is a cost effective and efficient improvement on previous static solar and it produce an environmentally friendly power supply.

The tracking system also displays important information that can be used for other fields of science such as temperature of the day and status of the tracker at all times. It will also have an interface with a personal computer where it can be controlled remotelly.

5.2.0 RECOMMENDATION

The following recommendations have been made for future studies and improvements

1. The tracker should be monitor record and store the data it read all through the day. This will provide more detailed information for use in other fields of sciences.
2. The bidirectional data should be improved track the position of the sun in four quadrants by measuring the position of maximum sun intensity on all the candinal points of the earth. This will eliminate trackinging losses experience as a result of change in season.
3. The tracker should be improved to have more intelligent algorithm and devices which can detect obstructions from clouds. This will improve the efficiency of the tracker.

4. The tracking system should be deployed in rural communities, where cost of deploying national electricity is not economical.
5. In future project I recommend that field programmable gate array (FPGA) processors or a PIC microcontroller that support several interupts should be used, so that all the interupts of the microcontroller can be operated independently.

REFERENCE

1. Gbayan B.M (2011), Journal of Applied Art and Science, Federal Polytechnic Bida.
2. Sybil P. parker, et al (1992), McGraw-Hill concise encyclopedia of science and technology, publication 3rd edition, pp 1727
3. The history of solar, US department of energy, energy efficiency and renewable energy
4. http://www.seia.org.au/history.html
5. Marliyani binti omar (2009), low cost solar tracker
6. Otono C.A. (2009), Design and construction of a microcontroller based solar tracker
7. IEEE NIGERCON (2010), proceeding on Emerging and sustainable technologies for power and ICT in a developing society pp97
8. Chukwu M.C. (2009), Design and construction of solar tracking system
9. http://en.wikipedia.org/wiki/Microcontroller
10. ATMEL (1999), 8bit microcontroller with 8k byte flash AT89C52
11. National instrument (2000), LM35 precision centigrade temperature sensors
12. http:en.wikipedia.org/wiki/solar_tracker
13. Intersil (2002), 8-bit microprocessor compatible A/D converters
14. Maxim (2001), +5V powered, multicannel RS-232 drivers/ receivers
15. HITACHI, HD44780U (LCD), Dot matrix crystal display controller driver