CHAPTER ONE

INTRODUCTION

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1.1 Background

The world population is increasing day by day and the demand for energy is increasing accordingly. An enormous amount of energy is extracted, distributed, converted and consumed in the global society daily. 85% of energy production is dependent on fossil fuels. The resources of the fossil fuels like oil and coal as the main source of energy nowadays, is expected to end up from the world during the recent century which explores a serious problem in providing the humanity with an affordable and reliable source of energy.

The need of the hour is renewable energy resources with cheap running costs. Renewable energy sources play an important role in electric power generation and it's generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves, and geothermal heat. Solar energy is considered as one of the main energy resources in warm countries.

Solar energy is a good choice for electric power generation, since the solar energy is directly converted into electrical energy by solar photovoltaic modules. These modules are made up of silicon cells. When many such cells are connected in series we get a solar PV module. The current rating of the modules increases when the area of the individual cells is increased, and vice versa. When many such PV modules are connected in series and parallel combinations we get solar PV arrays, that suitable for obtaining higher power output.

The applications for solar energy are increased, and that need to improve the materials and methods used to harness this power source. Main factors that affect the efficiency of the collection process are solar cell efficiency, intensity of source radiation and storage techniques. The efficiency of a solar cell is limited by materials used in solar cell manufacturing. It is particularly difficult to make considerable improvements in the performance of the cell, and hence restricts the efficiency of the overall collection process. Therefore, the increase of the intensity of radiation received from the sun is the most attainable method of improving the performance of solar power. There are three major approaches for maximizing power extraction in solar systems. They are sun tracking, Maximum Power Point (MPP) tracking or both.

Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. As such, it is vital that those in engineering fields understand the technologies associated with this area. This thesis will include the design and implementation of a microcontroller-based solar panel tracking system. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun. The system will tend to maximize the amount of power absorbed by photo voltaic systems. It has been estimated that the use of a tracking system, over a fixed system, can increase the power output by 30% - 60% [1]. The increase is significant enough to make tracking a viable preposition despite of the enhancement in system cost.

Solar trackers are devices used to orient photovoltaic panels, reflectors, lenses or other optical devices toward the sun. A working system will ultimately be demonstrated to validate the design. 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. As we know, using solar photovoltaic cells for producing energy is very expensive especially in the small application. For that reason, the efficiency of PV systems should be increase by maximize the sun light it capture. In order to maximize power output, needs to keep the panels aligned with the sun in any time. Always, in the bad weather or in the autumn specifically when the sky gets cloudy, these will decrease the incident light from the sun on both photo resisters according to that the system stop tracking which reduces the efficiency of the system to solve this problem a technique is used here called scan technique.

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 is always changes depends on the movement of the sun in a day. However, sunlight is bad when the weather is bad or the sky is cloudy.

1.3 Objectives

The aim of the thesis is to keep the solar photovoltaic panel perpendicular to the sun in order to make it more efficient**.**

1.4 Methodology

- Study the solar system as a renewable energy.
- Identify the problem that shading effect.
- Design and implementation of a solar panel tracking system using AT mega 16 microcontroller and tow LDR sensors.
- Evaluate performance of the solar system based on results.

1.5 Research Outline

Chapter two reviews the solar tracking system and discusses some of the important previous works that are proposed in solar tracking system. Chapter three describes the hardware components which are used in the electronic circuit design. The simulation results and discussion are obtained in chapter four. Finally, chapter five contains the conclusion and recommendations.

CHAPTER TWO

SOLAR TRACKING SYSTEM

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2.1 Overview

One of the most important problems facing the world today is the energy problem. This problem is resulted from the increase of demand for electrical energy and raised of fossil fuel prices. Another problem in the world is the global climate change has increased. As these problems alternative technologies for producing electricity have received greater attention. The most important solution was in finding other renewable energy resources [2]. Several researchers have studied the solar tracking systems with different modes and electromechanical module to improve the efficiency of solar systems. The design of tracker was based on some criteria: low cost, easy maintenance, modular, low energy consumption, and easy adjustment in case of different location.

2.2 Literature Review

A. B. Afarulrazi, W. M. Utomo, K.L. Liew and M. Zarafi are designed and developed an automatic Solar Tracker Robot (STR) which is capable to track maximum light intensity. The efficiency of the solar energy conversion can be optimized by receiving maximum light on the solar panel. STR is microcontroller based and built to move the solar panel in one axis, which is from east to west and vice versa. Servo motor is the actuator used to move the solar panel due to the high torque and small in size. The STR will automatically adjust the position of the robot so that it always faces the same direction. This will ensure the solar panel receiving optimum sunlight if external force is applied to move the STR [3].

Md. Tanvir Arafat Khan, S. M. Shahrear Tanzil and Rifat Rahman are described a microcontroller based design methodology of an automatic solar tracker. Light dependent resistors are used as the sensors of the solar tracker. The designed tracker has precise control mechanism which will provide three ways of controlling system. A small prototype of solar tracking system is also constructed to implement the design methodology presented here. In this paper, the design methodology of a microcontroller based simple and easily programmed automatic solar tracker is presented. A prototype of automatic solar tracker ensures feasibility of this design methodology [4].

Nader Barsoum is designed and constructed of a prototype for solar tracking system with two degrees of freedom, which detects the sunlight using photocells. The control circuit for the solar tracker is based on a PIC16F84A microcontroller (MCU). This is programmed to detect the sunlight through the photocells and then actuate the motor to position the solar panel where it can receive maximum sunlight. This paper is about moving a solar panel along with the direction of sunlight; it uses a gear motor to control the position of the solar panel, which obtains its data from a PIC16F84A microcontroller. The objective is to design and implement an automated, double-axis solar tracking mechanism using embedded system design in order to optimize the efficiency of overall solar energy output [5].

Aleksandar Stjepanovic, Sladjana Stjepanovic, Ferid Softic and Zlatko Bundalo are designed and constructed of a microcontroller based solar panel tracking system. Solar tracking allows more energy to be produce because the solar array is able to remain aligned to the sun. The paper begins with presenting background theory in light sensors and stepper motors as they apply to the project. In the conclusions are given discussions of design results. The paper begins with presenting background theory, light sensors and stepper motors as they apply to the project. The paper continues with specific design methodologies pertaining to photocells, stepper motors and drivers, microcontroller selection, voltage regulation, physical construction, and a software/system operation explanation. The paper concludes with a discussion of design results and future work [6].

Lwin Lwin Oo and Nang Kaythi Hlaing are developed and implemented a prototype of two axis solar tracking system based on a PIC microcontroller. The parabolic reflector or parabolic dish is constructed around two feed diameter to capture the sun’s energy. The focus of the parabolic reflector is theoretically calculated down to an infinitesimally small point to get extremely high temperature. This two axis auto-tracking system has also been constructed using PIC 16F84A microcontroller. The assembly programming language is used to interface the PIC with two-axis solar tracking system. The temperature at the focus of the parabolic reflector is measured with temperature probes. This auto-tracking system is controlled with two 12V, 6W DC gear box motors. The five light sensors LDR are used to track the sun and to start the operation (Day/Night operation). Time delays are used for stepping the motor and reaching the original position of the reflector. The two-axis solar tracking system is constructed with both hardware and software implementations. The designs of the gear and the parabolic reflector are carefully considered and precisely calculated [7].

Daniel A. Pritchard had given the design, development, and evaluation of a microcomputer-based solar tracking system [8]. Then many studies for solar tracking appeared using the microprocessor, Saxena and Dutta in 1990 [9].

A. Konar and A.K. Mandal [10], and A. Zeroual in 1997 using electro-optical sensors for sun finding [11]. The microcontroller is used as base for automatic sun tracker to control a dc motor in 1998 by F. Huang [12], and used as base for maximum power point tracking controller by Eftichios Koutroulis in 2001[13].

Hasan A. Yousef, had given the PC-based fuzzy logic controller design and Implementation to control a sun tracking system in 1999, the tracking system was driven by two permanent magnet DC motors to provide motion of the PV panels in two axes [14].

Chee-Yee Chong, in 2000 had given the process architectures for track fusion, they Presented different approaches for fusing track state estimates, and compared their performance through theoretical analysis and simulations, they used the concept of multiple targets tracking because it had shown that tracking with multiple sensors can provide better performance than using a single sensor [15].

Manny studies for novel Maximum Power Point Tracking (MPPT) controller for a photovoltaic energy conversion System was proposed by Yeong Chau Kuo in 2001[16], K. K. Tse in 2002[17], and Henry Shu-Hung Chung in 2003[18], Kimiyoshi Kohayashi in 2004[19]. Z.G. Piao, proposed a solar tracking system in 2003, using DC motors, special motors like stepper motors, servo motors, real time actuators, to operate moving parts, it was highly expensive [20]. A. A.Khalil, had presented a sun tracking system in 2003, This Tracking system easy to implement and efficient for solar energy collection [21].

Manny methods was proposed to achieve the objective of maximum power point tracking, and the active sun tracking scheme without any light sensors, S. Armstrong et al. had proposed a quantitative measure of the effectiveness MPPT efficiency in 2005, a vector methodology was used to track the direction and path of the sun throughout the day[22]. And Rong-Jong Wai. Had given grid connected photovoltaic generation system with an adaptive step-perturbation method and an active sun tracking scheme in 2006[23]. Cemil Sungur had given the electromechanical control system of a photovoltaic (PV) panel tracking the sun using Programmable Logic Controls (PLC) in 2007[24].

2.3 Renewable Energy

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are naturally replenished. In its various forms, it derives directly from the sun, or from heat generated deep within the Earth [25]. Figure 2.1 shows that natural gas and nuclear power are expected to grow slowly over the next 40 years, at which point natural gas will start its decline. It is also hoped that a new clean energy source of fusion energy will be demonstrated at increasing scales from 2030 to 2070 which will then become commercially competitive [26]. Renewable energy replaces conventional fuels in four distinct areas: power generation, water and space heating, transport fuels, rural and remote areas energy services. Globally, an estimated 193 million households depends on renewable energy systems.

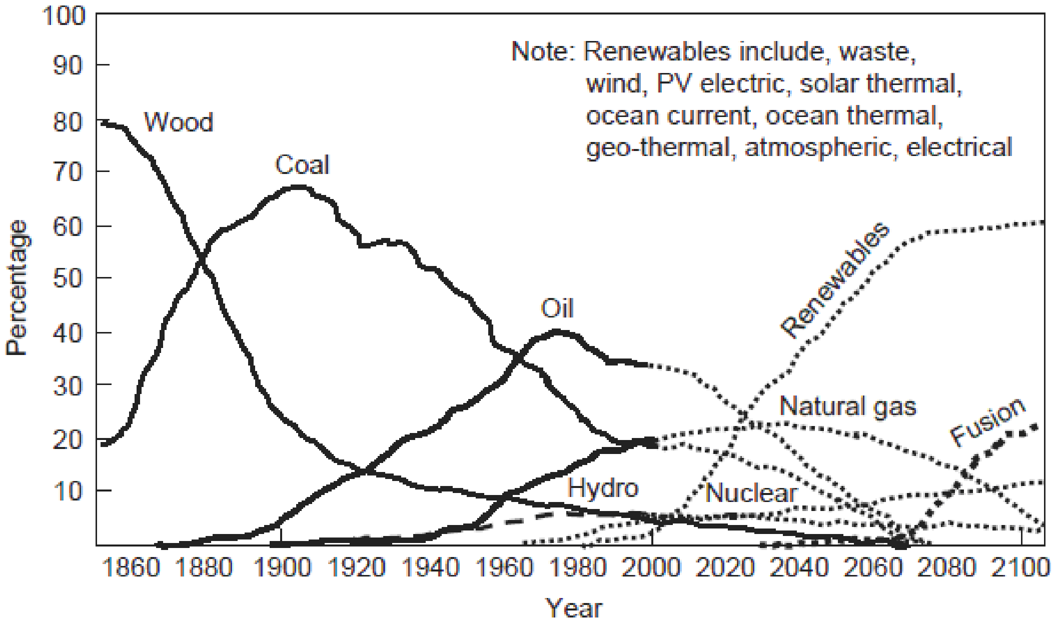

Figure 2.1: Principle of solar cells

The most important of renewable energy is solar energy; however, grid-connected PV increased the fastest of all renewable technologies, with a 60-percent annual average growth rate for the five-year period. Nowadays, solar energy has been widely used in our life, and it's expected to grow up in the next years.

2.4 Solar Energy

Solar energy is the term used for the heat and light which the sunlight contains. Sunlight reaches to Earth in the form of photons. Photons are energy packets that contain light in it. Solar energy is considered as a renewable energy source because it does not destroy our eco system and is present naturally in the environment. There are many advantage for using solar energy, solar power is non-polluting. It usage does not emit any greenhouse gases or harmful waste as we know the large effect of these kind of gases on the environment. Solar power is perfect and saving for power generation in remote areas or where the cost of expansion utility grid is high.

2.5 Electricity from Solar Power

Solar power is the form of energy that helps in generation of electricity from the sunrays. There are many methods to generate electric current using sunlight but the most common methods are photovoltaic and concentrated solar power. Solar panels are made up of photovoltaic cells; it means the direct conversion of sunlight to electricity by using a semiconductor, usually made of silicon. The word photovoltaic comes from the Greek meaning light (photo) and electrical (voltaic). The need for low cost electric power in isolated areas is the primary force driving the world-wide photovoltaic industry today.

Photovoltaic contains an array of solar cells which are pressed in solar panels. These solar panels are protected and framed by a glass sheet. This sheet does not allow any impurities to pass in. Hence only sunrays can make their way in these solar panels are made up of conductive materials like impure silicon and copper indium mostly. These conductors help and support the flow of electrons, thus the heat present on the solar panels is able to generate direct electric current. This electric current cannot support the electrical devices. Therefore, it is converted to alternative current by using inverter and battery.

Photovoltaic energy is growing rapidly and it is so far the only rapidly progressing renewable energy technology. Concentrating Solar Power (CSP) systems work on the principle of converging the sunlight form many kilometers to single focal point. The concentrated energy stored in this form is converted to thermal energy which is utilized to support photovoltaic cell. The solar energy stored by CSP is also helpful in running steam turbines [27]. Figure 2.2 shows the principle of photovoltaic cell.

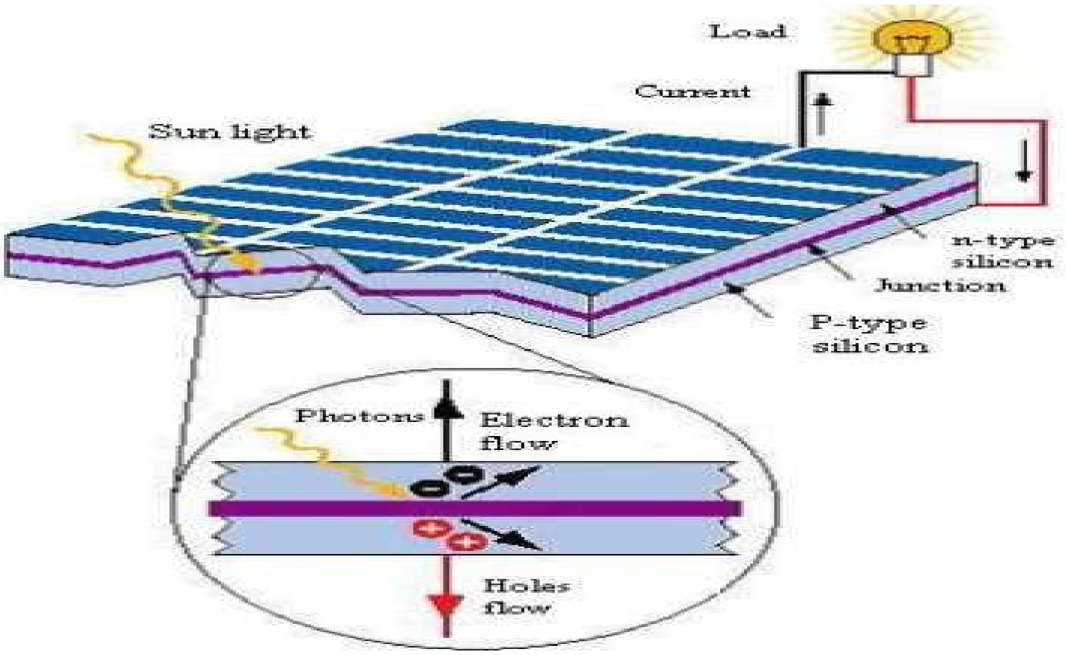

Figure 2.2: Principle of photovoltaic cell

2.6 Solar Tracker

Solar tracker is a device which follows the movement of the sun as it rotates from the east to the west every day. Trackers are used to keep solar panels oriented directly towards the sun as it moves through the sky every day. Using solar trackers increases the amount of solar energy which is received by the solar energy collector and improves the generated energy.

Electro optical control unit tracks the sun by a solar detecting device that is sensitive to solar radiance photo sensors produce a signal relative to the sun light that falls on them. Changes according to the movement of the sun occur in the signals produced by photo sensors. These different signals, which reach the control system, are evaluated and the required instruction signal is sent to the motor, which moves the solar panel. The panel moves according to this control signal and the movement of the panel stops at the position where it directly faces the sun, when the signals from photo sensors reach the value. A solar tracker is an electro-mechanical system used on behalf of orienting a solar photovoltaic panel in the direction of the sun. It is used in many applications such as the transportation signaling, lighthouses and emergency phones installed in the highways. Its main objective is to find the maximum sun radiations in order to get maximum charge for the batteries [28].

2.7 Tracking Technique

The sun rises each day from the east, and moves across the sky to the west. When the sun is shining, it is sending energy to us, and we can feel its 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. A 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. There are two general forms of tracking techniques used: dynamic tracking and fixed control algorithms. The main difference between them is the manner in which the path of the sun is determined. In the dynamic tracking system, actively searches for the sun's position at any time of day, light sensors are positioned on the tracker at various locations or in specially 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 which direction the tracker has to tilt in order to be facing the sun. Since the sensory data is continuous, the system can follow (track) the sun's movement across the sky. On the other hand in the fixed control algorithm systems, the control system uses no sensing. It does not actively find the sun's position but instead determines the position of the sun through prerecorded data for a particular site. If given the current time, day, month and year, then the system calculates the position of the sun, so it is called open loop trackers. Common to both forms of tracking is the method of direction control system. The dynamic tracking system is studied in this research.

2.8 Solar Collector

The main types of solar collector are:

2.8.1 Flat-plate collectors

Flat-plate collectors are the more commonly used type of collector today. They are arrays of solar panels arranged in simple plane. They can be of nearly any size, and have an output that is directly related to a few variables including size, facing, and cleanliness. These variables all affect the amount of radiation that falls on the collector. Often these collector panels have automated machinery that keeps them facing the sun. The additional they take in due to the correction of facing more than compensates for the energy needed to drive the extra machinery.

2.8.2 Focusing collector

Focusing collectors are essentially flat-plate collectors with optical devices arranged to maximize the radiation falling on the focus of the collector. These are currently used only in a few scattered areas. Solar furnaces are examples of this type of collector. Although they can produce far greater amounts of energy at a single point than the flat-plate collectors can, they lose some of the radiation that the flat-plate panels do not. Radiation reflected off the ground will be used by flat-plate panels but usually will be ignored by focusing collectors (in snow covered regions, this reflected radiation can be significant). One other problem with focusing collectors in general is due to temperature. The fragile silicon components that absorb the incoming radiation lose efficiency at high temperatures, and if they get too hot they can even be permanently damaged. The focusing collectors by their very nature can create much higher temperatures and need more safeguards to protect their silicon components [29].

2.8.3 Passive collectors

Passive collectors are completely different from the other two types of collectors. The passive collectors absorb radiation and convert it to heat naturally, without being designed and built to do so. All objects have this property to some extent, but only some objects (like walls) will be able to produce enough heat to make it worthwhile. Often their natural ability to convert radiation to heat is enhanced in some way or another (by being painted black, for example) and a system for transferring the heat to a different location is generally added.

2.9 Types of Solar Panels

There are different types of solar panels which differ in them material, price and efficiency. Since the efficiency is the percentage of solar energy that is captured and converted into electricity. The efficiency values which gives are an average percentage of efficiency, because it's difficult to give an exact number for the different types of solar panels output.

- Monocrystalline solar panels: have efficiency approximately 18%. They are made from a large crystal of silicon. These types of solar panels are the most efficient. However, they are the most expensive. They do somewhat better in lower light conditions than the other types of solar panels.Figure 2.3 shows the monocrystalline solar panels.

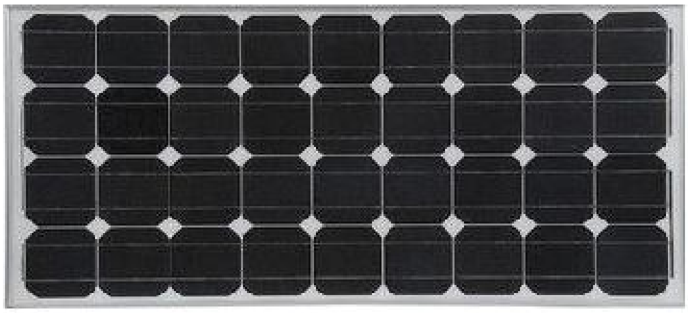

Figure 2.3: Monocrystalline solar panels

- Polycrystalline solar panels: have efficiency approximately 15%. Instead of one large crystal, this type of solar panel consists of multiple amounts of smaller silicon crystals. They are the most common type of solar panels on the market today. They look a lot like shattered glass. Figure 2.4 shows the polycrystalline solar panels.

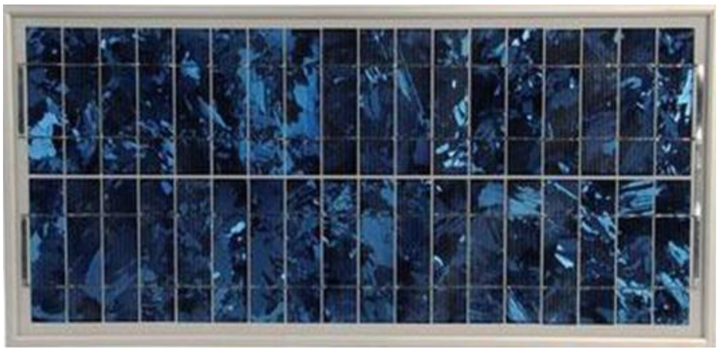

Figure 2.4**:** Polycrystalline solar panels

- Amorphous solar panels: have efficiency approximately 10%. Consisting of a thin-like film made from molten silicon that is spread directly across large plates of stainless steel or similar material. One advantage of amorphous solar panels over the other two is that they are shadow protected. That means when a part of the solar panel cells are in a shadow the solar panel continues to charge. This type of solar panels is the cheapest to produce. These work great on boats and other types of transportation. Figure 2.5 shows the amorphous solar panels.

Figure 2.5: Amorphous solar panels

2.10 Concentrated Photovoltaic Trackers

The optics in Concentrated Photo Voltaic (CPV) modules accept the direct component of the incoming light and therefore must be oriented appropriately to maximize the energy collected. In low concentration applications a portion of the diffuse light from the sky can also be captured. The tracking functionality in CPV modules is used to orient the optics such that the incoming light is focused to a photovoltaic collector. CPV modules that concentrate in one dimension must be tracked normal to the sun in one axis. CPV modules that concentrate in two dimensions must be tracked normal to the sun in two axes.

2.10.1 Single axis trackers

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 single axis trackers have one degree of freedom that acts as an axis of rotation tracking algorithms. There are several common implementations of single axis trackers. These include Horizontal Single Axis Trackers (HSAT), Vertical Single Axis Trackers (VSAT), Tilted Single Axis Trackers (TSAT) and Polar Aligned Single Axis Trackers (PASAT). The orientation of the module with respect to the tracker axis is important when modeling performance. Figure 2.6 shows the single axis tracker [30].

Figure 2.6**:** Single axis tracker

2.10.2 Dual Axis Trackers

Dual axis trackers have two degrees of freedom that act as axes of rotation. These axes are typically normal to one another. The axis that is fixed with respect to the ground can be considered a primary axis. The axis that is referenced to the primary axis can be considered a secondary axis. There are several common implementations of dual axis trackers. They are classified by the orientation of their primary axes with respect to the ground. Two common implementations are Tip-Tilt Dual Axis Trackers (TTDAT) and Azimuth-Altitude Dual Axis Trackers (AADAT). The orientation of the module with respect to the tracker axis is important when modeling performance. Dual axis trackers typically have modules oriented parallel to the secondary axis of rotation. Dual axis trackers allow for optimum solar energy levels due to their ability to follow the sun vertically and horizontally. No matter where the sun is in the sky, dual axis trackers are able to angle themselves to be in direct contact with the sun. Figure 2.7 shows the dual axis tracker [30].

Figure 2.7**:** Dual axis tracker

2.11 Advantage of Solar Tracker

The main reason to use a solar tracker is to reduce the cost of the energy we want to capture. A tracker produces more power over a longer time than a stationary array with the same number of modules. This additional output or gain can be quantified as a percentage of the output of the stationary array. Gain varies significantly with latitude, climate, and the type of tracker you choose—as well as the orientation of a stationary installation in the same location. The energy required to move the tracker is insignificant in these calculations. Climate is the most important factor. The more sun and less clouds, moisture, haze, dust, and smog, the greater the gain provided by trackers. At higher latitudes gain will be increased due to the long arc of the summer sun.

2.12 Drive Types

There are two types of derive trackers are:

2.12.1 Active tracker

Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Active two-axis trackers are also used to orient heliostats – movable mirrors that reflect sunlight toward the absorber of a central power station. As each mirror in a large field will have an individual orientation these are controlled programmatically through a central computer system, which also allows the system to be shut down when necessary. Light-sensing trackers typically have two or more photo sensors, such as photodiodes, configured differentially so that they output a null when receiving the same light flux. Mechanically, they should be unidirectional (i.e. flat) and are aimed 90 degrees apart. This will cause the steepest part of their cosine transfer functions to balance at the steepest part, which translates into maximum sensitivity.

Since the motors consume energy, one wants to use them only as necessary. So instead of a continuous motion, the heliostat is moved in discrete steps. Also, if the light is below some threshold there would not be enough power generated to warrant reorientation. This is also true when there is not enough difference in light level from one direction to another, such as when clouds are passing overhead. Consideration must be made to keep the tracker from wasting energy during cloudy periods [29].

2.12.2 Passive tracker

Passive trackers use a low boiling point compressed gas fluid that is driven to one side or the other (by solar heat creating gas pressure) to cause the tracker to move in response to an imbalance. As this is a non-precision orientation it is unsuitable for certain types of concentrating photovoltaic collectors but works fine for common PV panel types. These will have viscous dampers to prevent excessive motion in response to wind gusts. Shader/reflectors are used to reflect early morning sunlight to wake up the panel and tilt it toward the sun, which can take nearly an hour. The time to do this can be greatly reduced by adding a self-releasing tie down that positions the panel slightly past the zenith (so that the fluid does not have to overcome gravity) and using the tie down in the evening. A slack-pulling spring will prevent release in windy overnight conditions.

The term passive tracker is also used for photovoltaic modules that include a hologram behind stripes of photovoltaic cells. That way, sunlight passes through the transparent part of the module and reflects on the hologram. This allows sunlight to hit the cell from behind, thereby increasing the module's efficiency. Also, the module does not have to move since the hologram always reflects sunlight from the correct angle towards the cells [31].

CHAPTER THREE

COMPONENTS DESCRIPTION

CHAPTER THREE

COMPONENTS DESCRIPTION

3.1 Solar Tracker

Solar tracker is basically a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. After finding the sunlight, the tracker will try to navigate through the path ensuring the best sunlight is detected. The design of the solar tracker requires many components work together harmoniously to achieve a smooth run for the solar tracker, they are:

- Methods of Tracker Mount.
- LDR sensors.
- Unipolar stepper motor.
- ULN2003 motor drive.
- AT mega 16 microcontroller.
- Power supply.
- Voltage regulator.
- 16*2 LCD display.
- Light emitting diode.

The block diagram which explains the general construction for the thesis is shown in Figure 3.1.

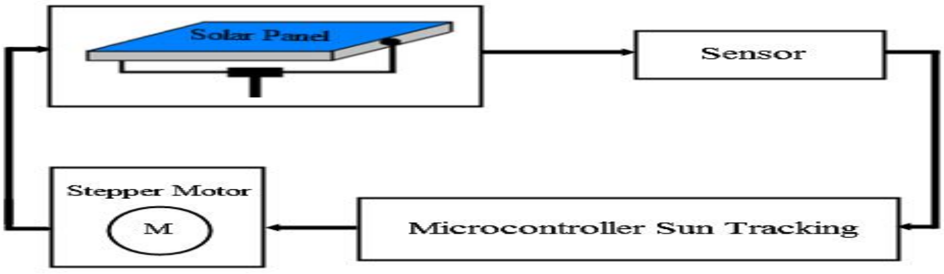

Figure 3.1 Block diagram of the main components

3.2 Methods of Tracker Mount

There are two methods of tracking mount which are single axis solar tracker and double axis solar tracker. In this thesis the first one is used. Single axis solar trackers can either have a horizontal or a vertical axle. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun does not get very high, but summer days can be very long. The single axis tracking system is the simplest solution and the most common one used. Double axis solar trackers have both a horizontal and a vertical axis.

3.3 Sensors

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument; here light dependent resistor is used. Light dependent resistor is made of a high-resistance semiconductor. It can also be referred to as a photoconductor. If light falling on the device is of the high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron conducts electricity, thereby lowering resistance. Hence, light dependent resistor is very useful in light sensor circuits. LDR is very high-resistance, sometimes as high as 10MΩ, when they are illuminated with light resistance drops dramatically.

A light dependent resistor is a resistor that changes in value according to the light falling on it. A commonly used device, the ORP-12, has a high resistance in the dark, and a low resistance in the light. Connecting the LDR to the microcontroller is very straight forward, but some software calibrating is required. It should be remembered that the LDR response is not linear, and so the readings will not change in exactly the same way as with a potentiometer. In general, there is a larger resistance change at brighter light levels. This can be compensated for in the software by using a smaller range at darker light levels. Figure 3.2 shows the LDR.

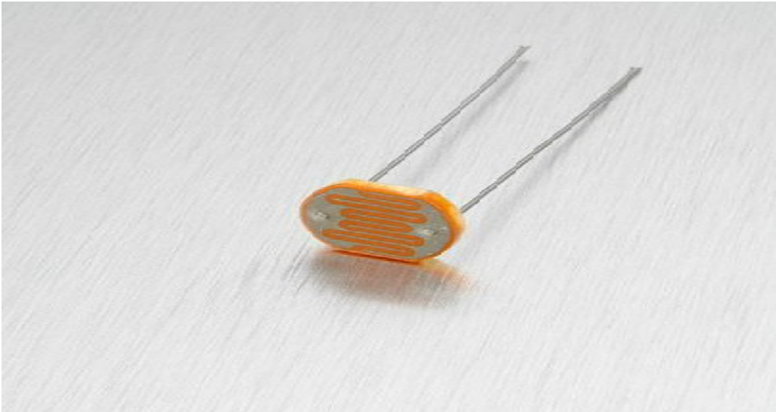

Figure 3.2: Light Dependent Resistor

In this thesis two LDR sensors are used. The concept of using two LDRs for sensing is that, the stable position is when the two LDRs having the same light intensity. When the light source moves, i.e. the sun from west to east, the level of intensity falling on both the LDRs changes and this change is calibrated into voltage using voltage dividers. The changes in voltage are compared using built-in comparator of microcontroller and motor is used to rotate the solar panel in a way so as to track the light source [32].

3.4 Stepper Motor

Unipolar stepper motor is used to drive the solar tracker to the best angle of exposure of light. The main features of stepper motor are:

- Linear speed control of stepper motor.
- Control of acceleration, deceleration, max speed and number of steps to move.
- Driven by one timer interrupt.
- Full - or half-stepping driving mode.
- Supports all AVR devices with 16bit timer.

The stepper motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation. Many advantages are achieved using this kind of motors, such as higher simplicity, since no brushes or contacts are present, low cost, high reliability, high torque at low speeds, and high accuracy of motion. Figure 3.3 shows the stepper motor.

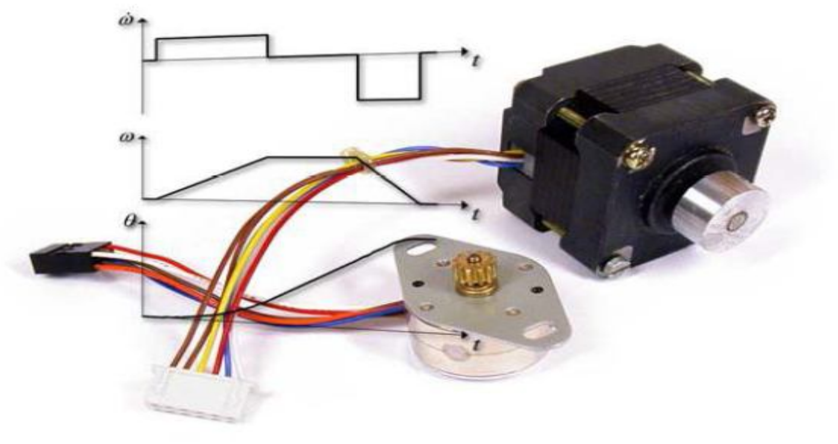

Figure 3.3: Stepper motor

Stepper motors require that their power supply be continuously pulsed in specific patterns. For each pulse the stepper motor moves around one step often 15 degrees giving 24 steps in a full revolution. There are two main types of stepper motors - unipolar and bipolar. Unipolar motors usually have four coils which are switched on and off in a particular sequence. Bipolar motors have two coils in which the current flow is reversed in a similar sequence. Each of the four coils in a unipolar stepper motor must be switched on and off in a certain order to make the motor turn. Many microprocessor systems use four output lines to control the stepper motor, each output line controlling the power to one of the coils. Here unipolar stepper motor is used [32].

Table 3.1: Unipolar stepper motor operation

Step	Coil 1	Coil 2	Coil 3	Coil 4
1	1	0	1	0
2	1	0	0	1
3	0	1	0	1
4	0	1	1	0
1	1	0	1	0

Table 3.1 shows the four different steps required to make the motor turn. Coil 2 is always the opposite or logical NOT of coil 1. The same applies for coils 3 and 4. It is therefore possible to cut down the number of microcontroller pins required to just two by the use of two additional NOT gates. Fortunately the darlington driver IC ULN2003 can be used to provide both the NOT and darlington driver circuits. It also contains the back emf suppression diodes so no external diodes are required.

3.5 ULN 2003 Motor Drive

ULN 2003 is a high voltage and high current darlington array IC. It contains seven open collectors darlington pairs with common emitters. A darlington pairs is an arrangement of two bipolar transistors. Figure 3.4 shows the ULN 2003. ULN 2003 belongs to the family of ULN 200X series of ICs. Different version of this family interface to different logic families. ULN 2003 is for 5V, COMS logic devices. These ICs are used when driving a wide range of loads and are used as relay drivers. ULN 2003 is also used while driving stepper motors. Each channel or darlington pair in ULN 2003 is rated at 500mA and can with stand peak current of 600mA. The inputs and outputs are provided opposite to each other in the pin layout. Each driver also contains a suppression diode to dissipate voltage spikes while driving inductive load.

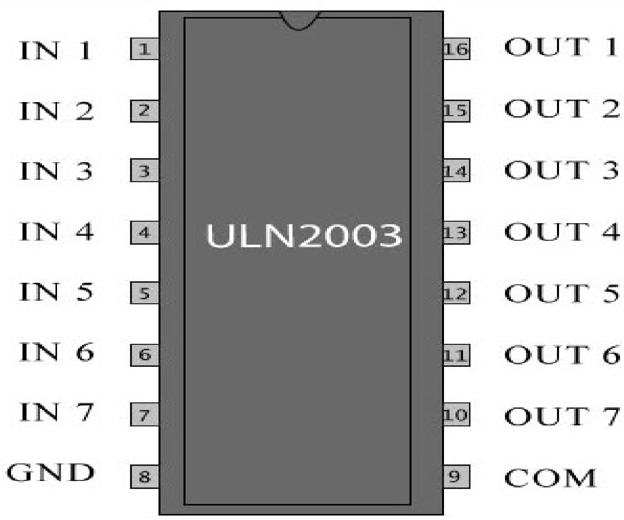

Figure 3.4: ULN 2003

3.6 ATmega16 Microcontroller

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. The program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems [32]. AT mega16 microcontroller is used for controlling the direction of stepper motor.

Microcontrollers, as stated, are inexpensive computers. The microcontroller has ability to store and run a unique program makes it extremely versatile. For instance one can program a microcontroller to makes decisions based on predetermined situations and selections .The microcontroller has ability to perform math and logic functions allows it to mimic sophisticated logic and electronic circuit. Figure 3.5 describes a general block diagram of microcontroller.

The pin descriptions of AT mega16 as follows:

VCC is the digital supply voltage.

GND is the ground.

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.

AREF is the analog reference pin for the A/D converter.

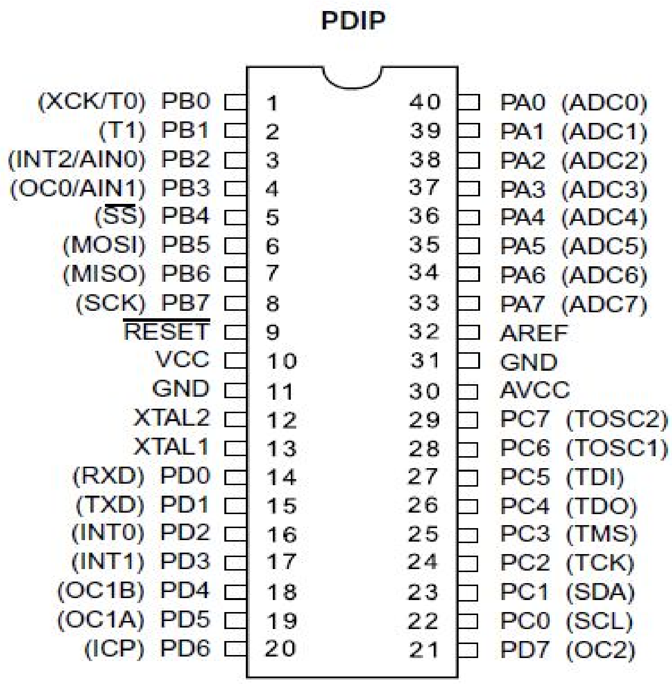

Figure 3.5: Pin diagram of ATmega16

Port A (PA7 – PA0) is the serves as the analog inputs to the A/D converter. Port A also serves as an 8-bit bi-directional I/O port, if the A/D converter is not used. Port pin scan provide internal pull-up resistors. The port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The port A pins are tri-stated when a reset condition becomes active, even if the clock is not running. Table 3.2 shows an alternate function of port A. If some port A pins are configured as outputs, it is essential that these do not switch when a conversion is in progress. This might corrupt the result of the conversion.

Port B (PB7 - PB0) is an 8-bit bi-directional I/O port with internal pull-up resistors. The port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port B pins that are externally pulled low will source current if the pull-up resistors are activated. The port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. The alternate pin configuration of port B is as follows:

Table 3.2**:** Port A pins alternate functions

Port Pin	Alternate Function
PA7	ADC7 (ADC input channel 7)
PA6	ADC6 (ADC input channel 6)
PA5	ADC5 (ADC input channel 5)
PA4	ADC4 (ADC input channel 4)
PA3	ADC3 (ADC input channel 3)
PA2	ADC2 (ADC input channel 2)
PA1	ADC1 (ADC input channel 1)
PA0	ADC0 (ADC input channel 0)

• SCK – port B, bit 7

SCK: Master clock output, slave clock input pin for SPI channel. When the SPI is enabled as a slave, this pin is configured as an input regardless of the setting of DDB7. When the SPI is enabled as a master, the data direction of this pin is controlled by DDB7. When the pin is forced by the SPI to be an input, the pull-up can still be controlled by the port B7 bit.

• MISO – port B, bit 6

MISO: Master data input, slave data output pin for SPI channel. When the SPI is enabled as a master, this pin is configured as an input regardless of the setting of DDB6. When the SPI is enabled as a slave, the data direction of this pin is controlled by DDB6. When the pin is forced by the SPI to be an input, the pull-up can still be controlled by the port B6 bit.

• MOSI – port B, bit 5

MOSI: SPI master data output, slave data input for SPI channel. When the SPI is enabled as a slave, this pin is configured as an input regardless of the setting of DDB5. When the SPI is enabled as a master, the data direction of this pin is controlled by DDB5. When the pin is forced by the SPI to be an input, the pull-up can still be controlled by the port B5 bit.

• SS – port B, bit 4

SS: Slave select input. When the SPI is enabled as a slave, this pin is configured as an input regardless of the setting of DDB4. As a slave, the SPI is activated when this pin is driven low. When the SPI is enabled as a master, the data direction of this pin is controlled by DDB4. When the pin is forced by the SPI to be an input, the pull-up can still be controlled by the port B4 bit.

• AIN1/OC0 – port B, bit 3

AIN1, Analog comparator negative input configures the port pin as input with the internal pull-up switched off to avoid the digital port function from interfering with the function of the analog comparator. OC0, output compare match output: The PB3 pin can serve as an external output for the timer/counter 0 compare match. The PB3 pin has to be configured as an output to serve this function. The OC0 pin is also the output pin for the PWM mode timer function.

• AIN0/INT2 – port B, bit 2

AIN0, Analog comparator positive input configures the port pin as input with the internal pull-up switched off to avoid the digital port function from interfering with the function of the analog comparator. INT2, external interrupt source 2: The PB2 pin can serve as an external interrupt source to the MCU.

• T1 – port B, bit 1

T1, Timer/counter1 counter source.

• T0/XCK – port B, bit 0

T0 Timer/Counter 0 counter source XCK USART external clock. The Data direction register DDB0 controls whether the clock is output DDB0 set or input DDB0 cleared. The XCK pin is active only when the USART operates in synchronous mode.

Port C (PC7 - PC0) is an 8-bit bi-directional I/O port with internal pull-up resistors. The port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port C pins that are externally pulled low will source current if the pull-up resistors are activated. The port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled**,** the pull-up resistors on pins PC5 (TDI), PC3 (TMS) and PC2 (TCK) will be activated even if a reset occurs. The alternate pin configuration of port C is as follows:

• TOSC2 – port C, bit 7

TOSC2, Timer oscillator pin 2: When the AS2 bit in ASSR is set one to enable asynchronous clocking of timer/counter 2, pin PC7 is disconnected from the port, and becomes the inverting output of the oscillator amplifier. In this mode, a crystal oscillator is connected to this pin, and the pin cannot be used as an I/O pin.

• TOSC1 – port C, bit 6

TOSC1, Timer oscillator pin 1: When the AS2 bit in ASSR is set one to enable asynchronous clocking of timer/counter 2, pin PC6 is disconnected from the port, and becomes the input of the inverting oscillator amplifier. In this mode, a crystal oscillator is connected to this pin, and the pin cannot be used as an I/O pin.

• TDI – port C, bit 5

TDI, JTAG test data in: Serial input data to be shifted in to the instruction register or data register. When the JTAG interface is enabled, this pin cannot be used as an I/O pin.

• TDO – port C, bit 4

TDO, JTAG test data out: Serial output data from instruction register or data register. When the JTAG interface is enabled, this pin cannot be used as an I/O pin. The TD0 pin is tri-stated unless TAP states that shifts out data are entered.

• TMS – port C, bit 3

TMS, JTAG test mode select: This pin is used for navigating through the TAP-controller state machine. When the JTAG interface is enabled, this pin cannot be used as an I/O pin.

• TCK – port C, bit 2

TCK, JTAG test clock: JTAG operation is synchronous to TCK. When the JTAG interface is enabled, this pin cannot be used as an I/O pin.

SDA – port C, bit 1

SDA, Two-wire serial interface data: When the TWEN bit in TWCR is set one to enable the two-wire serial interface, pin PC1 is disconnected from the port and becomes the serial data I/O pin for the two-wire serial interface. In this mode, there is a spike filter on the pin to suppress spikes shorter than 50 ns on the input signal, and the pin is driven by an open drain driver with slew-rate limitation. When this pin is used by the two-wire serial interface, the pull-up can still be controlled by the portC1 bit.

• SCL – port C, bit 0

SCL, Two-wire serial interface clock: When the TWEN bit in TWCR is set one to enable the two-wire serial interface, pin PC0 is disconnected from the port and becomes the serial clock I/O pin for the two-wire serial interface. In this mode, there is a spike filter on the pin to suppress spikes shorter than 50 ns on the input signal, and the pin is driven by an open drain driver with slew-rate limitation. When this pin is used by the two-wire serial interface, the pull-up can still be controlled by the port C0 bit.

Port D (PD7 - PD0) is an 8-bit bi-directional I/O port with internal pull-up resistors. The port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port D pins that are externally pulled low will source current if the pull-up resistors are activated. The port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

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

XTAL2 is the output from the inverting oscillator amplifier.

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

Programming of AT mega 16 requires several hardware and software tools. The software tools as BASCOM software. Hardware tools as a universal programmer is used to program the AT mega 16. This programmer provides the hardware interface between the host PC and the AT mega16 for the machine code loading.

3.7 Power Supply

AT mega 16 can operate with a power supply of +2.5V to +5.5V. Usually a voltage regulator circuit is used to obtain the required power supply voltage when the device is operated from a mains adapter battery. Here the voltage is taken from +9V adapter as shown in Figure 4.5, this adapter can be replaced by battery.

Figure 3.6: Adapter +9V

3.8 Voltage Regulator

The AT mega 16 needs a regulated supply DC voltage of 5 Volts, the 7805 voltage regulator is used to provide the voltage required by the microcontroller. The top view of the regulator itself is shown in Figure 3.7.

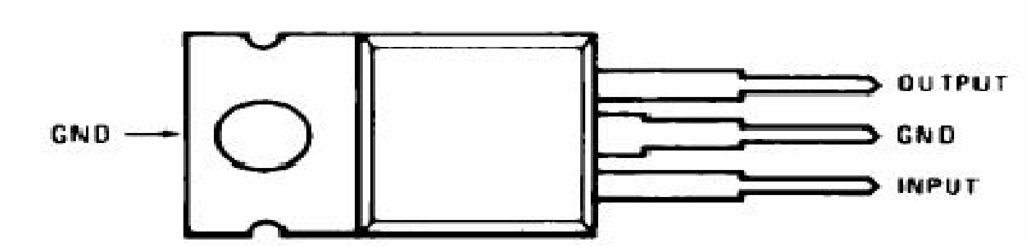

Figure 3.7: Voltage regulator

The circuit of Figure 3.8 shows how to convert the unregulated supply of 9V to 5V, the capacitor of 0.1 microfarad is placed between the input and output to smoothen and maintain the voltage [33].

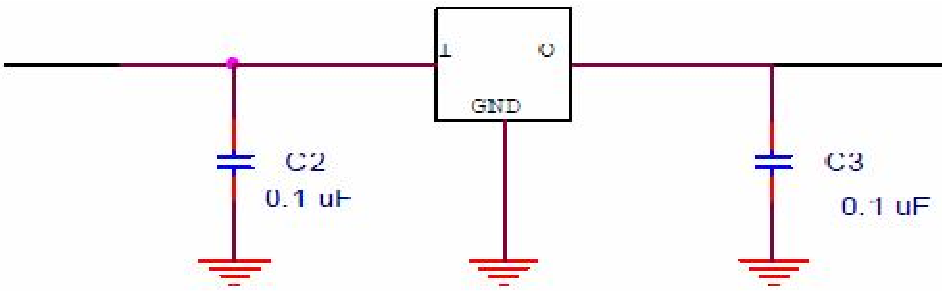

Figure 3.8: Voltage regulator circuit

3.9 LCD Display

A Liquid Crystal Display (LCD) is an electronic device that can be used to show numbers or text. There are two main types of LCD display, numeric display and alphanumeric text displays. The display is made up of a number of shaped crystals. In numeric displays these crystals are shaped into bars, and in alphanumeric displays the crystals are simply arranged into patterns of dots. Each crystal has an individual electrical connection so that each crystal can be controlled independently. When the crystal is off i.e. when no current is passed through the crystal, the crystal reflect the same amount of light as the background material, and so the crystals cannot be seen. However, when the crystal has an electric current passed through it, it changes shape and so absorbs more light. This makes the crystal appear darker to the human eye - and so the shape of the dot or bar can be seen against the background. It is important to realise the difference between a LCD display and an LED display. An LED display often used in clock radios is made up of a number of

LEDs which actually give off light and so can be seen in the dark. An LCD display only reflect slight, and so cannot be seen in the dark. The dot-matrix liquid crystal display controller and driver LSI displays alphanumeric, 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/driver. A single HD44780U can display up to two 8-character lines 16 x 2. A16 x 2 line LCD module to display user information.

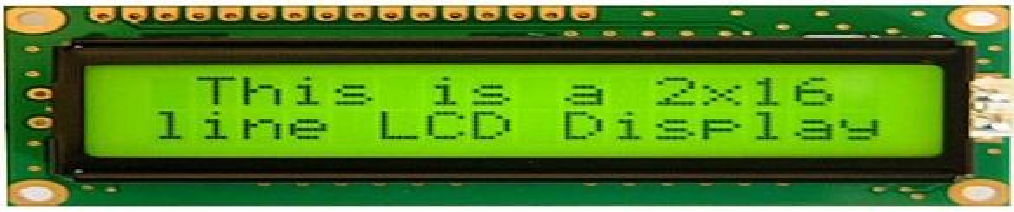

Figure 3.9: 2x16 LCD display

3.10 Light Emitting Diode

An LED is a very simple electronics component which lights up when electricity flows through it. Since it is a diode, electricity can only flow one way. There is usually a flat section on the side of the LED to mark its polarity: this side should be connected to ground. This side usually also has a shorter leg. In order to prevent too much current flowing through an LED and damaging it, it should be connected in series with a resistor.

Figure 3.10: Light emitting diode

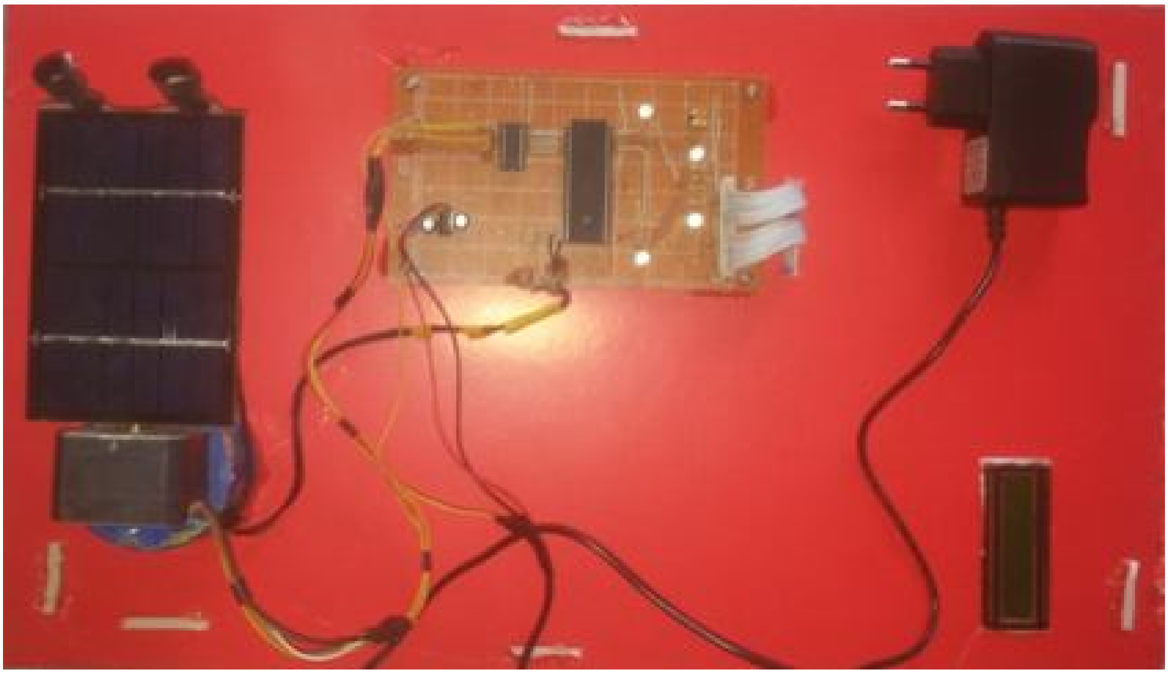

Figure 3.11: The complete circuit design of the sun tracking system

CHAPTER FOUR

RESULTS AND DISCUSSION

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Schematic Diagram

Figure 4.1 shows the complete simulation schematic diagram of the solar tracking system using Proteus Software.

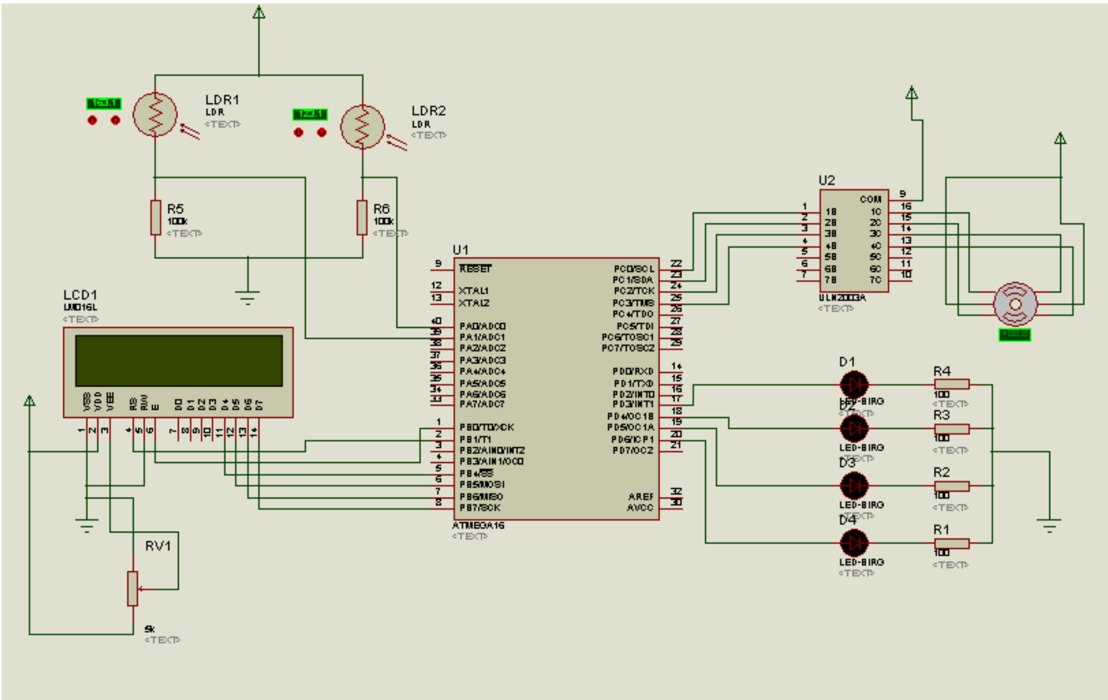

Figure 4.1: Schematic diagram of the solar system

4.2 Operation of the Solar Tracker System Using a Scan Technique

Solar tracker provides two modes of operation and control mechanism through the program written in microcontroller. The tow modes are:

(a) Normal day light condition (track mode): Two photo resistors are used in the solar tracker to compare the output voltages from two junctions. As the sun rotates from east to west in the day time, LDR1 needs to provide higher voltage than LDR2 to sense the rotation of the sun. This condition is considered as normal day light condition and tracker rotates the panel to track the sun.

(b) Bad weather condition (scan mode): When the sky gets cloudy, there will be less striking of light on both the photo resistors and so sufficient voltages might not be available at junction point. The difference of voltage at junction point will not be greater than the threshold value to rotate the tracker. At the meantime, sun continues rotating in the western direction. To solve this problem a new technique is used here based on the program that can operate the system, this technique known as scan technique.

This technique is to keep the tracker (when the sun is despaired for a long time) search for the new position of the sun automatically (that was known as scan mode) and stop searching when the light is detected and the sun is found. When the system is due to its natural position and continues the process of tracking. Also this method support bidirectional rotation means that, at day time when the solar tracker will rotate in only one direction from east to west. For the next day, the solar panel does not need to go to the initial position in the morning to track the sun, because the scan mode can operate the system when the sun wasn't found for any reasons.

4.3 Flow Chart and Main Program

The software program is written by basic language (See Appendix A) and the flow chart which explains the steps of the software program is shown in Figure 4.2.

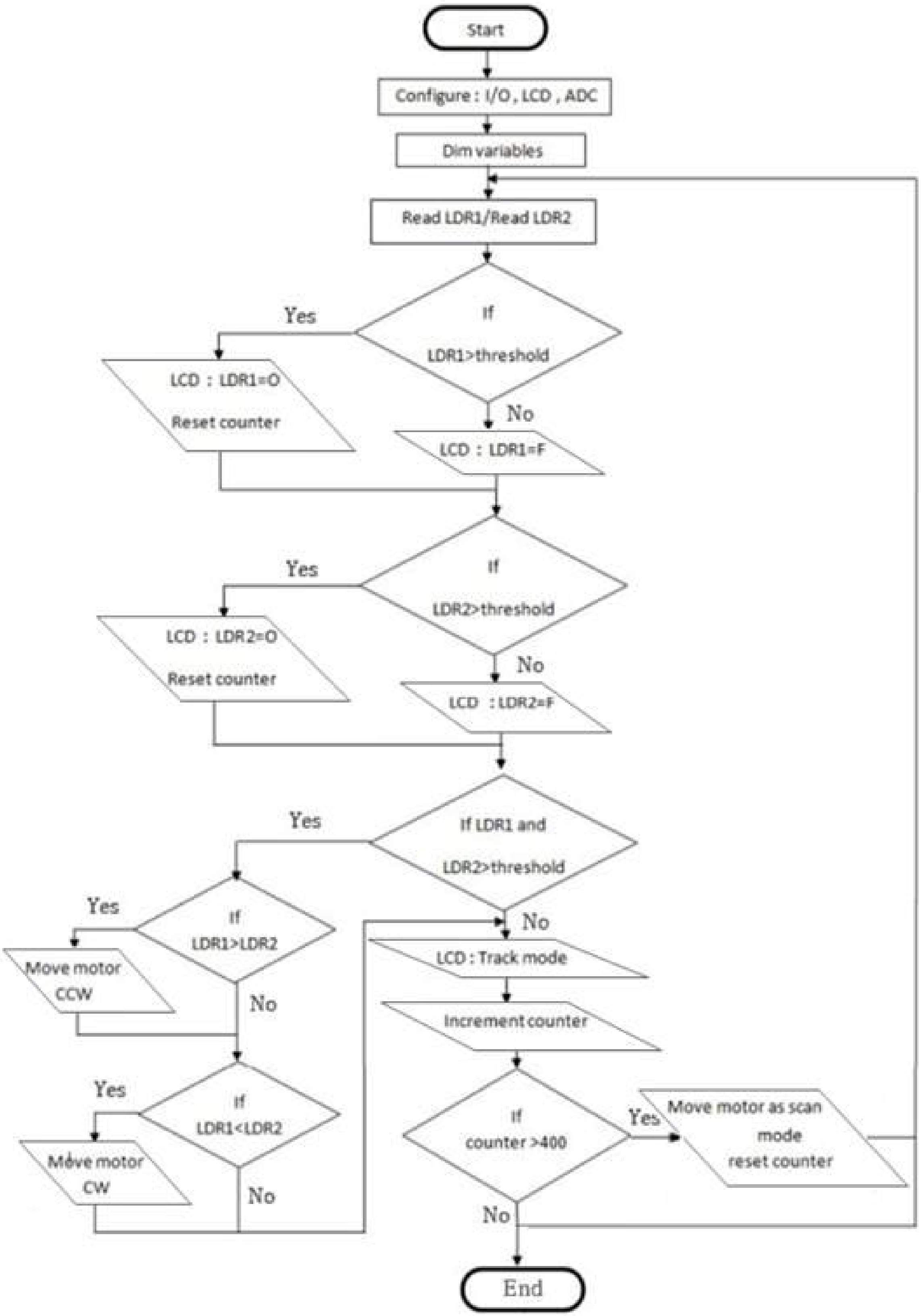

Figure 4.2: Flow chart of the main program

4.4 Results

After the completion of the circuit design and make sure it works properly. The operation of the solar tracker is simple to understand, it works by using an AT mega 16 microcontroller which compares the light intensity illuminated onto the LDRs, and sends an output signal to let the motor moves clockwise and counter clock wise respectively. For the stepper motor it's important to know its step angle that will be used to make the panel align to the sun. Step angle of the stepper motor is defined as the angle traversed by the motor in one step. To calculate step angle, simply divide 360 by number of steps a motor takes to complete one revolution. The unipolar stepper motor that used in this thesis contains 200 steps per full rotation. The step angle calculates as:

$$\text{step angle} = \frac{360}{number\ of\ steps} \qquad (4.1)$$

Then each step have step angle $= \frac{360}{200} = 1.8°$. The effective portion for the whole number of steps that must rotate the solar tracker is half of the total number of steps equal 100 step. This thesis also have 25 modes represent the movement of the solar tracker, each mode include number of steps. The main aim of these calculations is to find the angle mode that will be used to obtain the angle rage corresponding to every mode. The numbers of steps in one mode are calculated as:

$$The\ number\ of\ steps\ in\ one\ mode = \frac{100}{25} = 4\ steps \qquad (4.2)$$

From the previous equation stepper motor rotating in full mode takes 4 steps to complete a revolution. Then the angle mode calculates as:

$$Angle\ mode = 4 \times 1.8 = 7.2° \qquad (4.3)$$

Finally, the circuit of the tracker contains 4 LEDs (2 LEDs of 4 work together as one LED) that’s means we have three LEDs to indicate the current location of the panel. Table 4.1 shows the relationship between the modes and the corresponding range angle and also which LED (ON or OFF) according to the mode.

Table 4.1: Relationship between modes, range angle and LED

Mode	Angle range	Led1	Led2	Led3
0	0 – 7.2°	ON	OFF	OFF
1	7.2° – 14.4°	ON	OFF	OFF
2	14.4° – 21.6°	ON	OFF	OFF
3	21.6° – 28.8°	ON	OFF	OFF
4	28.8° – 36°	ON	OFF	OFF
5	36° – 43.2°	ON	OFF	OFF
6	43.2° – 50.4°	ON	OFF	OFF
7	50.4° – 57.6°	ON	OFF	OFF
8	57.6° – 64.8°	ON	OFF	OFF
9	64.8° – 72°	ON	OFF	OFF
10	72° – 79.2°	ON	OFF	OFF
11	79.2° – 86.4°	OFF	ON	OFF
12	86.4° – 93.6°	OFF	ON	OFF
13	93.6° – 100.8°	OFF	ON	OFF
14	100.8° – 108°	OFF	ON	OFF
15	108° – 115.2°	OFF	OFF	ON
16	115.2° – 122.4°	OFF	OFF	ON
17	122.4° – 129.6°	OFF	OFF	ON
18	129.6° – 136.8°	OFF	OFF	ON
19	136.8° – 144°	OFF	OFF	ON
20	144° – 151.2°	OFF	OFF	ON
21	151.2° – 158.4°	OFF	OFF	ON
22	158.4° – 165.6°	OFF	OFF	ON
23	165.6° – 172.8°	OFF	OFF	ON
24	172.8° – 180°	OFF	OFF	ON

4.5 Discussion

The logic that works on the microcontroller to detect the signal is based on the threshold value that will read by LDRs, this is necessary in order to set the pre-scalars on the program that will be stored inside the microcontroller. On the other hand, this design work in 24 modes as we know, every mode have a corresponding angle range as shown in Table 4.1 and here we have some illustrative examples to explain these modes.

For example, in morning when sun rises in the east first LDR getting maximum intensity of light than the other as shown in figure 4.3.

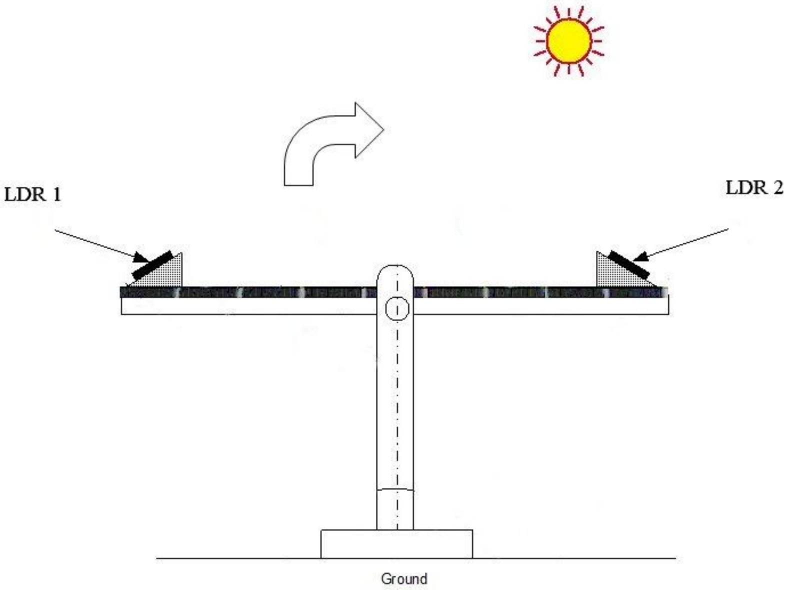

Figure 4.3: Illustrative example 1 (a)

The motor rotates in a specified angle to keep the panel perpendicular to the light. The stable position is when the tow LDRs having the same light intensity as shown in Figure 4.4.

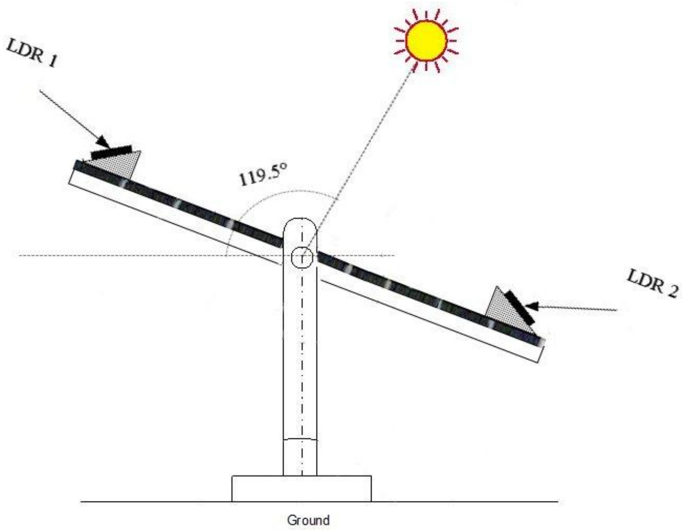

Figure 4.4: Illustrative example 1 (b)

The angle 119.5° includes in mode 16, LED3 is ON and the other two LEDs is OFF to indicate the current position of the light and the system is work.

The next example, when sometimes latter second LDR will get maximum light than the other as shown in Figure 4.5.

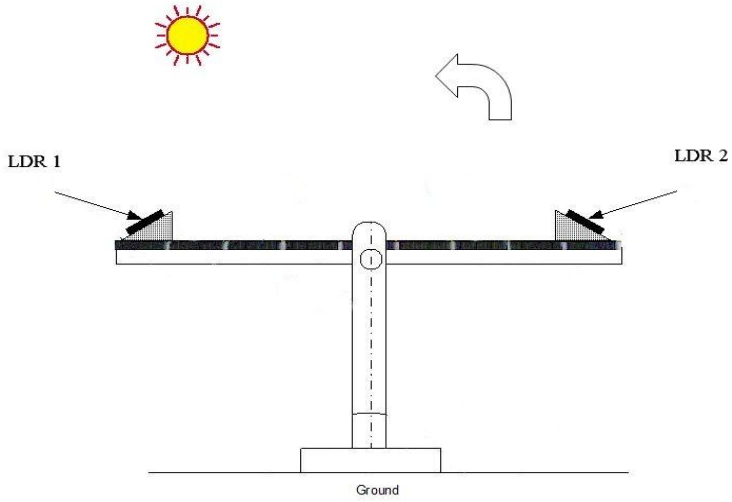

Figure 4.5: Illustrative example 2 (a)

Then stepper motor rotates to specified angle to make the tow LDRs read the same light intensity also to keep the panel perpendicular to the light as shown in Figure 4.6.

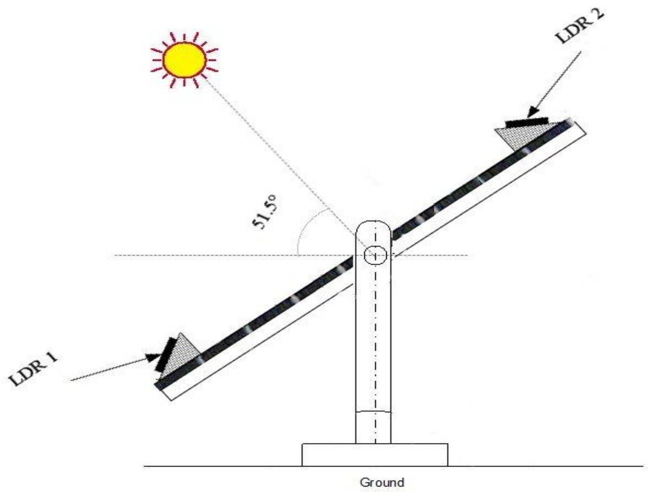

Figure 4.6: Illustrative example 2 (b)

The angle 51.5° includes in mode 7, LED1 is ON and the other two LEDs is OFF to indicate the current position of the light and the system is work.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this thesis a sun tracking system has been developed to increase the amount of power generated by the solar panel as the sun traverses across the sky. An ATmega16 microcontroller used to control the movement of the solar panel. Solar energy is one of the most popular renewable sources nowadays. It is being widely used also, and within some more years it will be very popular that it will be used for many purposes, in industries and household as well. So it is most important fact to utilize the maximum energy of the sun so that maximum power can be generated. The thought behind this thesis is also derived from this fact. In many places experiment is being done on this fact how it is possible to make full use of the day light. The biggest problems facing researchers in this area are poor weather problems or when the sky get a cloudy, meaning the disappearance of the sun light from the optical sensor for a long period of time, which makes the LDR sensor does not read the sun light falling on it, which stops the tracking process, on the other hand when the sun re-appear the LDR sensor cannot able to read the incident light from the sun because the location of the sun is changed. This design represents a new method (technique) for solving this problem, this method depend on the program written in a microcontroller is known as scan technique, the system according to this program is able to work in two mode, first one when the system is work in a normal conditions known as track mode, the tracker follow the sun easily from east to west. The second one is that when the system work in bad weather conditions, the system in this state is operate under scan mode technique , this technique is based on the self-search (scan) system to sunlight After all specified period of time. This method is made the system more accurate and it is expected to increase the efficiency of the panel.

As per energy concerned solar energy is one of the most promising energy which is going to be a main source of energy in near future. As today's world need greater amount of energy it can be satisfy by using this project.

5.2 Recommendations

To apply this system in a practical experiment , large solar cell must used for real live to give a power that can use, however large motor and big motor drive should be inserted to rotate the panel easily. To increase the efficiency and accuracy of this system, Real Time Clock (RTC) also should be use to avoid night scan. RTC need to add a keypad for the main circuit to adjust it to be modified from country zone time to another. Another approach is using the GPS system that we provide it with our place and time zone and it give us the sun position longitude and latitude, then we can use this calculation to locate the solar tracker also.

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APPENDICES

Appendix (A)

Main Program

APPENDIX A

MAIN PROGRAM

```
$regfile = "m16def.dat"
$crystal = 8000000
Config Portc.0 = Output                'stepper motor
Config Portc.1 = Output                'stepper motor
Config Portc.2 = Output                'stepper motor
Config Portc.3 = Output                'stepper motor
Config Portd.3 = Output                'led
Config Portd.4 = Output                'led
Config Portd.5 = Output                'led
Config Portd.6 = Output                'led
Config Lcd = 16 * 2
Config Lcdpin = Pin , Db4 = Portb.4 , Db5 = Portb.5 , Db6 = Portb.6 , Db7 =
Portb.7 , E = Portb.0 , Rs = Portb.1
Config Adc = Single , Prescaler = Auto , Reference = Avcc
Dim Ldr1 As Word
Dim Ldr2 As Word
Dim T As Byte
Dim D1 As Byte
Dim D2 As Byte
Dim Q1 As Byte
Cls
Cursor Off
Locate 1 , 1
```

```
Lcd "   Sun Track"
Locate 2 , 1
Lcd "     System"
Wait 2
Cls
Dim C As Word
First:
Do
Ldr1 = Getadc(0)
Waitms 10
Ldr2 = Getadc(1)
If Ldr1 > 950 Then
Locate 1 , 1
Lcd "Ldr1=O"
Else
Locate 1 , 1
Lcd "Ldr1=F"
End If
If Ldr2 > 950 Then
Locate 1 , 9
Lcd "Ldr2=O"
Else
Locate 1 , 9
Lcd "Ldr2=F"
End If
```

```
If Ldr1 > 950 Or Ldr2 > 950 Then
C = 0
If Ldr1 > Ldr2 Then
Gosub Mccw
Elseif Ldr1 < Ldr2 Then
Gosub Mcw
End If
End If
Locate 2 , 1
Lcd "TRACK MODE " ; Q1 ; "  "
Incr C
If C > 400 Then
Cls
Locate 2 , 1
Lcd "  SCAN MODE "
Wait 2
Locate 1 , 1
Lcd "  BACK HOME "
Wait 2
Portd.6 = 0, Portd.5 = 0, Portd.4 = 0, Portd.3 = 0
Gosub Mhome
Q1 = 0
Wait 3
Cls
Locate 2 , 1
```

```
Lcd " FINE SCANING.."

Wait 1

T = 0

Cls

Gosub Cw

Gosub Ccw

Cls

C = 0

End If

If Q1 = 1 Or Q1 = 2 Or Q1 = 3 Or Q1 = 4 Or Q1 = 5 Or Q1 = 6 Or Q1 = 7 Or Q1 = 8 Or Q1 = 9 Or Q1 = 10 Then

Portd.6 = 1 Portd.5 = 0 Portd.4 = 0 Portd.3 = 0

Elseif Q1 = 11 Or Q1 = 12 Or Q1 = 13 Or Q1 = 14 Then

Portd.6 = 0 Portd.5 = 1 Portd.4 = 1 Portd.3 = 0

Elseif Q1 = 15 Or Q1 = 16 Or Q1 = 17 Or Q1 = 18 Or Q1 = 19 Or Q1 = 20 Or Q1 = 21 Or Q1 = 22 Or Q1 = 23 Or Q1 = 24 Then

Portd.6 = 0 Portd.5 = 0 Portd.4 = 0 Portd.3 = 1

End If

Loop

Mcw:

If Q1 < 24 Then

Incr Q1

End If

Portc.0 = 1 Portc.1 = 0 Portc.2 = 0 Portc.3 = 0

Waitms 20

Portc.0 = 0 Portc.1 = 1 Portc.2 = 0 Portc.3 = 0
```

```
Waitms 20

Portc.0 = 0 Portc.1 = 0 Portc.2 = 1 Portc.3 = 0

Waitms 20

Portc.0 = 0 Portc.1 = 0 Portc.2 = 0 Portc.3 = 1

Waitms 20

Portc.0 = 0 Portc.1 = 0 Portc.2 = 0 Portc.3 = 0

Return

Mccw:

If Q1 > 0 Then

Decr Q1

End If

Portc.0 = 1 Portc.1 = 0 Portc.2 = 0 Portc.3 = 0

Waitms 20

Portc.0 = 0 Portc.1 = 0 Portc.2 = 0 Portc.3 = 1

Waitms 20

Portc.0 = 0 Portc.1 = 0 Portc.2 = 1 Portc.3 = 0

Waitms 20

Portc.0 = 0 Portc.1 = 1 Portc.2 = 0 Portc.3 = 0

Waitms 20

Portc.0 = 1 Portc.1 = 0 Portc.2 = 0 Portc.3 = 0

Waitms 20

Portc.0 = 0 Portc.1 = 0 Portc.2 = 0 Portc.3 = 0

Return

Cw:

For T = 0 To 24
```

```
If Q1 < 24 Then
Incr Q1
End If
Portc.0 = 1 Portc.1 = 0 Portc.2 = 0 Portc.3 = 0
Waitms 30
Portc.0 = 0 Portc.1 = 1 Portc.2 = 0 Portc.3 = 0
Waitms 30
Portc.0 = 0 Portc.1 = 0 Portc.2 = 1 Portc.3 = 0
Waitms 30
Portc.0 = 0 Portc.1 = 0 Portc.2 = 0 Portc.3 = 1
Waitms 250
Ldr1 = Getadc(0)
Waitms 10
Ldr2 = Getadc(1)
If Ldr1 > 950 Then
Locate 1 , 1
Lcd "Ldr1=O"
Else
Locate 1 , 1
Lcd "Ldr1=F"
End If
If Ldr2 > 950 Then
Locate 1 , 9
Lcd "Ldr2=O"
Else
```

```
Locate 1 , 9

Lcd "Ldr2=F"

End If

If Ldr1 > 950 Or Ldr2 > 950 Then

Cls

Locate 1 , 1

Lcd " LIGHT DETECTED"

Portc.0 = 0 Portc.1 = 0 Portc.2 = 0 Portc.3 = 0

Wait 2

Cls

Locate 1 , 1

Lcd "SWITCH TO TRACK"

Locate 2 , 1

Lcd "    MODE"

Wait 2

Cls

T = 0, C = 0
Gosub First
End If
```

Appendix (B)

AT Mega16 Microcontroller

APPENDIX B

AT MEGA16 MICROCONTROLLER

Features

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories
  - 16K Bytes of In-System Self-Programmable Flash
    Endurance: 10,000 Write/Erase Cycles
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - 512 Bytes EEPROM
    Endurance: 100,000 Write/Erase Cycles
  - 1K Byte Internal SRAM
  - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
    8 Single-ended Channels
    7 Differential Channels in TQFP Package Only
    2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, and 44-pad MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega16L
  - 4.5 - 5.5V for ATmega16
- Speed Grades
  - 0 - 8 MHz for ATmega16L
  - 0 - 16 MHz for ATmega16
- Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L
  - Active: 1.1 mA
  - Idle Mode: 0.35 mA
  - Power-down Mode: < 1 µA

8-bit AVR® Microcontroller with 16K Bytes In-System Programmable Flash

ATmega16
ATmega16L

Summary

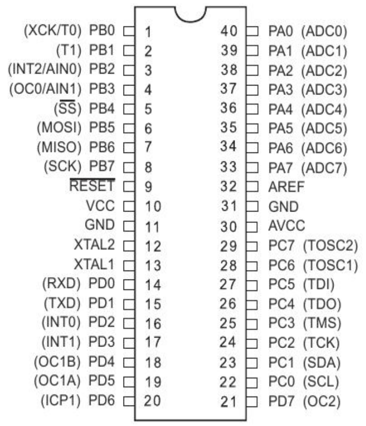
2466HS–AVR–12/03

Note: This is a summary document. A complete document is available on our Web site at www.atmel.com.

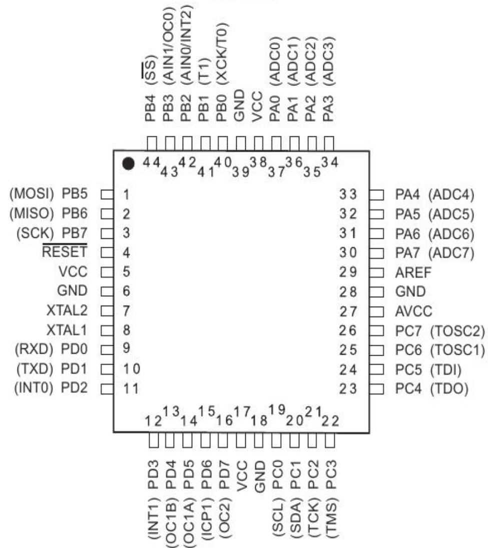
Pin Configurations

Figure 1. Pinouts ATmega16

PDIP



TQFP/MLF



Disclaimer

Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

Appendix (C)

Light Dependent Resistor

APPENDIX C

LIGHT DEPENDENT RESISTOR

SUNROM TECHNOLOGIES
Your Source for Embedded Systems

Email: info@sunrom.com or sunrom@gmail.com
Visit us at http://www.sunrom.com

Document: Datasheet Date: 28-Jul-08 Model #: 3190 Product's Page: www.sunrom.com/p-510.html

Light Dependent Resistor - LDR

Two cadmium sulphide(cds) photoconductive cells with spectral responses similar to that of the human eye. The cell resistance falls with increasing light intensity. Applications include smoke detection, automatic lighting control, batch counting and burglar alarm systems.

Applications

Photoconductive cells are used in many different types of circuits and applications.

Analog Applications

- Camera Exposure Control
- Auto Slide Focus - dual cell
- Photocopy Machines - density of toner
- Colorimetric Test Equipment
- Densitometer
- Electronic Scales - dual cell
- Automatic Gain Control – modulated light source
- Automated Rear View Mirror

Digital Applications

- Automatic Headlight Dimmer
- Night Light Control
- Oil Burner Flame Out
- Street Light Control
- Absence / Presence (beam breaker)
- Position Sensor

Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Unit
Cell resistance	1000 LUX 10 LUX	- -	400 9	- -	Ohm K Ohm
Dark Resistance	-	-	1	-	M Ohm
Dark Capacitance	-	-	3.5	-	pF
Rise Time	1000 LUX 10 LUX	- -	2.8 18	- -	ms ms
Fall Time	1000 LUX 10 LUX	- -	48 120	- -	ms ms
Voltage AC/DC Peak		-	-	320	V max
Current		-	-	75	mA max
Power Dissipation				100	mW max
Operating Temperature		-60	-	+75	Deg. C

Guide to source illuminations

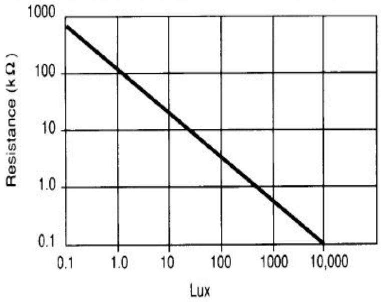
Light source Illumination	LUX
Moonlight	0.1
60W Bulb at 1m	50
1W MES Bulb at 0.1m	100
Fluorescent Lighting	500
Bright Sunlight	30,000

FIGURE 1 CIRCUIT SYMBOL

Sensitivity

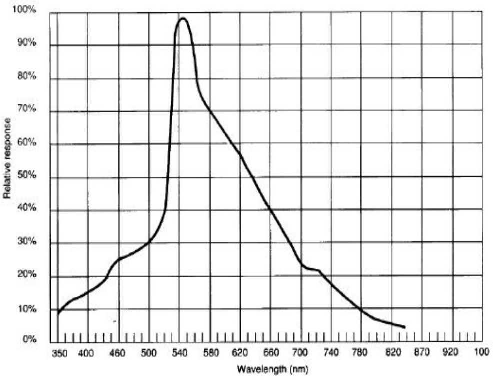
The sensitivity of a photodetector is the relationship between the light falling on the device and the resulting output signal. In the case of a photocell, one is dealing with the relationship between the incident light and the corresponding resistance of the cell.

FIGURE 2 RESISTANCE AS FUNCTION OF ILLUMINATION



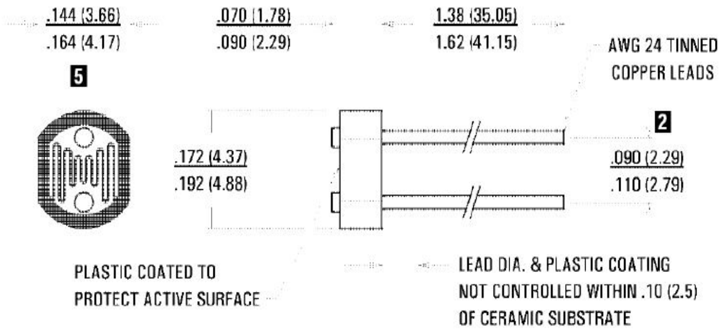
Spectral Response

Figure 3 Spectral response



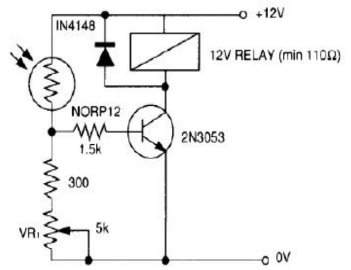
Like the human eye, the relative sensitivity of a photoconductive cell is dependent on the wavelength (color) of the incident light. Each photoconductor material type has its own unique spectral response curve or plot of the relative response of the photocell versus wavelength of light.

Dimensions



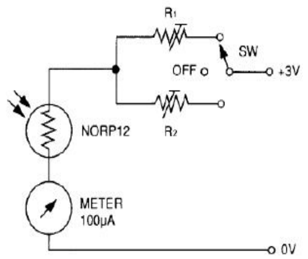
Typical Application Circuits

Figure 6 Sensitive light operated relay



Relay energised when light level increases above the level set by VR_1

Figure 9 Logarithmic law photographic light meter



Typical value R^1 = 100kΩ
R^2 = 200kΩ preset to give two overlapping ranges.
(Calibration should be made against an accurate meter.)

Appendix (D)

ULN 2003

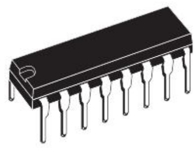
APPENDIX D

ULN 2003

ULN2001A-ULN2002A
ULN2003A-ULN2004A

SEVEN DARLINGTON ARRAYS

- SEVEN DARLINGTONS PER PACKAGE
- OUTPUT CURRENT 500mA PER DRIVER (600mA PEAK)
- OUTPUT VOLTAGE 50V
- INTEGRATED SUPPRESSION DIODES FOR INDUCTIVE LOADS
- OUTPUTS CAN BE PARALLELED FOR HIGHER CURRENT
- TTL/CMOS/PMOS/DTL COMPATIBLE INPUTS
- INPUTS PINNED OPPOSITE OUTPUTS TO SIMPLIFY LAYOUT



DIP16

ORDERING NUMBERS: ULN2001A/2A/3A/4A

SO16

ORDERING NUMBERS: ULN2001D/2D/3D/4D

DESCRIPTION

The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current darlington arrays each containing seven open collector darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

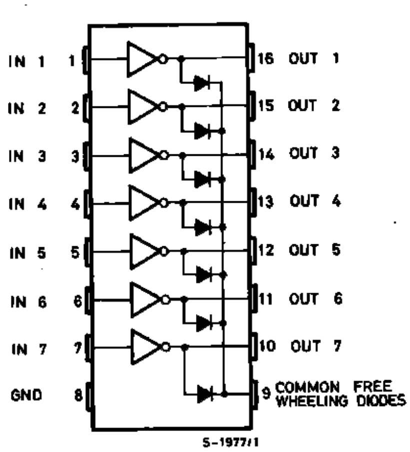
The four versions interface to all common logic families :

ULN2001A	General Purpose, DTL, TTL, PMOS, CMOS
ULN2002A	14-25V PMOS
ULN2003A	5V TTL, CMOS
ULN2004A	6–15V CMOS, PMOS

These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors, LED displays filament lamps, thermal printheads and high power buffers.

The ULN2001A/2002A/2003A and 2004A are supplied in 16 pin plastic DIP packages with a copper leadframe to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D/2002D/2003D/2004D.

PIN CONNECTION



Appendix (E)

LCD Display

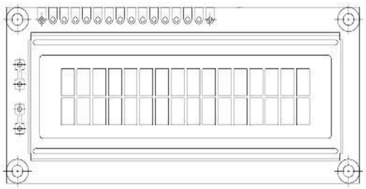
APPENDIX E

LCD DISPLAY

LCD-016M002B

Vishay

16 x 2 Character LCD



FEATURES

- 5 x 8 dots with cursor
- Built-in controller (KS 0066 or Equivalent)
- + 5V power supply (Also available for + 3V)
- 1/16 duty cycle
- B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED)
- N.V. optional for + 3V power supply

MECHANICAL DATA

ITEM	STANDARD VALUE	UNIT
Module Dimension	80.0 x 36.0	mm
Viewing Area	66.0 x 16.0	mm
Dot Size	0.56 x 0.66	mm
Character Size	2.96 x 5.56	mm

ABSOLUTE MAXIMUM RATING

ITEM	SYMBOL	STANDARD VALUE			UNIT
		MIN.	TYP.	MAX.	
Power Supply	VDD-VSS	- 0.3	–	7.0	V
Input Voltage	VI	- 0.3	–	VDD	V

NOTE: VSS = 0 Volt, VDD = 5.0 Volt

ELECTRICAL SPECIFICATIONS

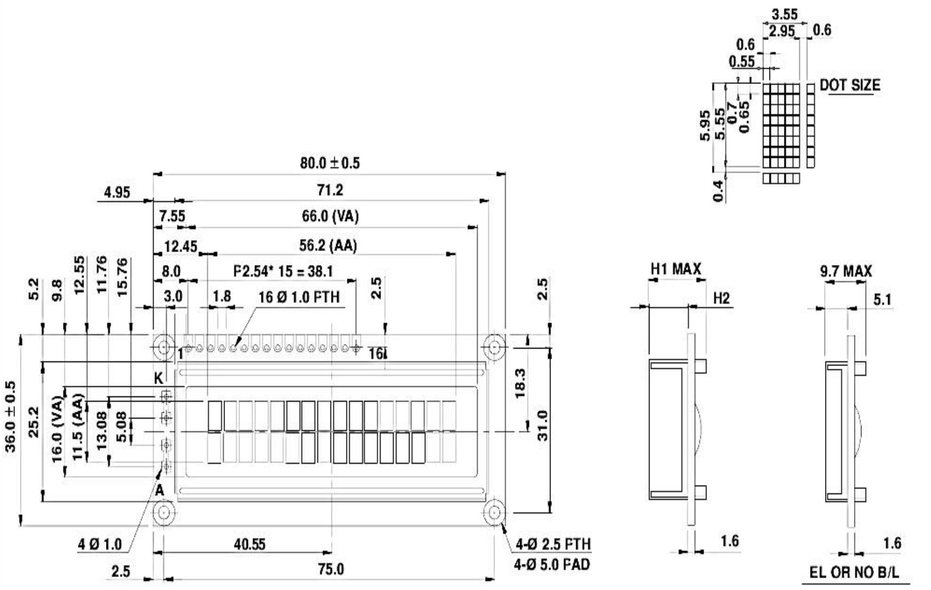
ITEM	SYMBOL	CONDITION		STANDARD VALUE			UNIT
				MIN.	TYP.	MAX.	
Input Voltage	VDD	VDD = + 5V		4.7	5.0	5.3	V
		VDD = + 3V		2.7	3.0	5.3	V
Supply Current	IDD	VDD = 5V		–	1.2	3.0	mA
Recommended LC Driving Voltage for Normal Temp. Version Module	VDD - V0	- 20 °C		–	–	–	V
		0°C		4.2	4.8	5.1	
		25°C		3.8	4.2	4.6	
		50°C		3.6	4.0	4.4	
		70°C		–	–	–	
LED Forward Voltage	VF	25°C		–	4.2	4.6	V
LED Forward Current	IF	25°C	Array	–	130	260	mA
			Edge	–	20	40	
EL Power Supply Current	IEL	Vel = 110VAC:400Hz		–	–	5.0	mA

DISPLAY CHARACTER ADDRESS CODE:

Display Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DD RAM Address	00	01														0F
DD RAM Address	40	41														4F

PIN NUMBER	SYMBOL	FUNCTION
1	Vss	GND
2	Vdd	+ 3V or + 5V
3	Vo	Contrast Adjustment
4	RS	H/L Register Select Signal
5	R/$\overline{W}$	H/L Read/Write Signal
6	E	H →L Enable Signal
7	DB0	H/L Data Bus Line
8	DB1	H/L Data Bus Line
9	DB2	H/L Data Bus Line
10	DB3	H/L Data Bus Line
11	DB4	H/L Data Bus Line
12	DB5	H/L Data Bus Line
13	DB6	H/L Data Bus Line
14	DB7	H/L Data Bus Line
15	A/Vee	+ 4.2V for LED/Negative Voltage Output
16	K	Power Supply for B/L (OV)

DIMENSIONS in millimeters



LED - H/L B/L

	HIGH	LOW
H1	13.2	12.1
H2	8.6	7.5