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MAXIMUM POWER SOLAR PANEL TRACKING SYSTEM

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Abstract: Solar energy is very important means of expanding renewable energy resources. In this paper is described the design and construction of a microcontroller based solar panel tracking system. Solar is a nonconventional source of energy, considering this we have developed solar panels so that we can fulfill our electricity need. But due to revolution of the earth, solar source i.e. sun does not face the panel continuously hence less electricity is produced. The energy panel should face the SUN till it is present in a day.

The problem above can be solved by our system by automatic tracking the solar energy. The block diagram below shows system architecture it consist of a LDR sensor senses max solar power which is being given to the Microcontroller through the ADC which digitizes the LDR output. Controller then takes the decision according to then algorithm and tilts the panel towards the direction of the max energy given by LDR with the help of DC Motor.

The Motor is used to rotate the LDR to sense the max solar power. A 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. It is completely automatic and keeps the panel in front of sun until that is visible. Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum. Residential that uses solar power as their alternative power supply will bring benefits to them. The main objective of this project is to development of an automatic solar tracking system whereby the system will caused solar panels will keep aligned with the Sunlight in order to maximize in harvesting solar power.

The system focuses on the controller design whereby it will caused the system is able to tracks the maximum intensity of Sunlight is hit. When the intensity of Sunlight is decreasing, this system automatically changes its direction to get maximum intensity of Sunlight. LDR light detector acts as a sensor is used to trace the coordinate of the Sunlight by detecting brightness level of Sunlight. While to rotate the appropriate position of the panel, a DC-geared motor is used. The system is controlled by two relays as a DC-geared motor driver and a microcontroller as a main processor. This project is covered for a single axis and is designed for low power and residential usage applications. From the hardware testing, the system is able to track and follow the Sunlight intensity in order to get maximum solar power at the output regardless motor speed.

I . INTRODUCTION

One of the most promising renewable energy sources characterized by a huge potential of conversion into electrical power is the solar energy. The conversion of solar radiation into electrical energy by Photo-Voltaic (PV) effect is a very promising technology, being clean, silent and reliable, with very small maintenance costs and small ecological impact. The interest in the Photo Voltaic conversion systems is visibly reflected by the exponential increase of sales in this market segment with a strong growth projection for the next decades. According to recent market research reports carried out by European Photovoltaic Industry Association (EPIA), the total installed power of PV conversion equipment increased from about 1 GW in 2001up to nearly 23 GW in 2009. The continuous evolution of the technology determined a sustained increase of the conversion efficiency of PV panels, but nonetheless the most part of the commercial panels have efficiencies no more than 20%. A constant research preoccupation of the technical community involved in the solar energy harnessing technology refers to various solutions to increase the PV panel‟s conversion efficiency. Among PV efficiency improving solutions we can mention: solar tracking, optimization of solar cells geometry, enhancement of light trapping capability, use of new materials, etc. The output power produced by the PV panels depends strongly on the incident light radiation. The continuous modification of the sun-earth relative position determines a continuously changing of incident radiation on a fixed PV panel. The point of maximum received energy is reached when the direction of solar radiation is perpendicular on the panel surface. Thus an increase of the output energy of a given PV panel can be obtained by mounting the panel on a solar tracking device that follows the sun trajectory. Unlike the classical fixed PV panels, the mobile ones driven by solar trackers are kept under optimum insolation for all positions of the Sun, boosting thus the PV conversion efficiency of the system. The output energy of PV panels equipped with solar trackers may increase with tens of percents, especially during the summer when the energy harnessed from the sun is more important. Photo-Voltaic or PV cells, known commonly as solar cells, convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in that they give off no noise and require practically no maintenance. A tracking system must be able to follow the sun with a certain degree of accuracy, return the collector to its original position at the end of the day and also track during periods of cloud over.

- The major components of this system are as follows.
- Light dependent resistor
- Microcontroller.
- Output mechanical transducer (stepper motor)

1.1 Background

A Solar Tracker is 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. The Solar Tracker will attempt to navigate to the best angle of exposure of light from the sun. This report aims to let the reader understand the project work which I have done. A brief introduction to Solar Panel and Solar Tracker is explained in the Literature Research section. Basically the Solar Tracker is divided into two main categories, hardware and software. It is further subdivided into six main functionalities: Method of Tracker Mount, Drives, Sensors, RTC, Motors, and Power Supply of the Solar Tracker is also explained and explored. The reader would then be brief with some analysis and perceptions of the information. By using solar arrays, a series of solar cells electrically connected, a DC voltage is generated which can be physically used on a load. Solar arrays or panels are being used increasingly as efficiencies reach higher levels, and are especially popular in remote areas where placement of electricity lines is not economically viable. This alternative power source is continuously achieving greater popularity especially since the realisation of fossil fuels shortcomings. Renewable energy in the form of electricity has been in use to some degree as long as 75 or 100 years ago. Sources such as Solar, Wind, Hydro and Geothermal have all been utilised with varying levels of success. The most widely used are hydro and wind power, with solar power being moderately used worldwide. This can be attributed to the relatively high cost of solar cells and their low conversion efficiency. Solar power is being heavily researched, and solar energy costs have now reached within a few cents per kW/h of other forms of electricity generation, and will drop further with new technologies such as titanium oxide cells. With a peak laboratory efficiency of 32% and average efficiency of 15-20%, it is necessary to recover as much energy as possible from a solar power system. This includes reducing inverter losses, storage losses, and light gathering losses. Light gathering is dependent on the angle of incidence of the light source providing power (i.e. the sun) to the solar cell‟s surface, and the closer to perpendicular, the greater the power. If a flat solar panel is mounted on level ground, it is obvious that over the course of the day the sunlight will have an angle of incidence close to 90° in the morning and the evening. At such an angle, the light gathering ability of the cell is essentially zero, resulting in no output. As the day progresses to midday, the angle of incidence approaches 0°, causing a steady increase in power until at the point where the light incident on the panel is completely perpendicular, and maximum power is achieved. As the day continues toward dusk, the reverse happens, and the increasing angle causes the power to decrease again toward minimum again. From this background, we see the need to maintain the maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible. By tilting the solar panel to continuously face the sun, this can be achieved. This process of sensing and following the position of the sun is known as Solar Tracking. It was resolved that real-time tracking would be necessary to follow the sun effectively, so that no external data would be required in operation.

1.2 Need of Solar Tracker

Photovoltaic's' is the field of technology and research related to the application of solar cells as solar energy. Solar cells have many applications. Individual cells are used for powering small devices such as electronic calculators. Photovoltaic arrays generate a form of renewable electricity, particularly useful in situations where electrical power from the grid is unavailable such as in remote area power systems, Earth-orbiting satellites and space probes, remote radiotelephones and water pumping applications. Photovoltaic electricity is also increasingly deployed in grid-tied electrical systems. Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. One of the most popular renewable energy sources is solar energy. Many researches were conducted to develop some methods to increase the efficiency of Photo Voltaic systems (solar panels). One such method is to employ a solar panel tracking system .This project deals with a microcontroller based solar panel tracking system. Solar tracking enables more energy to be generated because the solar panel is always able to maintain a perpendicular profile to the sun's rays. Development of solar panel tracking systems has been ongoing for several years now. As the sun moves across the sky during the day, it is advantageous to have the solar panels track the location of the sun, such that the panels are always perpendicular to the solar energy radiated by the sun. This will tend to maximize the amount of power absorbed by PV systems. It has been estimated that the use of a tracking system, over a fixed system, can increase the power output by 30% - 60%. The increase is significant enough to make tracking a viable preposition despite of the enhancement in system cost. It is possible to align the tracking heliostat normal to sun using electronic control by a micro controller.

1.3 Types of Solar Trackers

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

SINGLE AXIS SOLAR TRACKERS
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 (such as in UK) where the sun does not get very high, but summer days can be very long. These have a manually adjustable tilt angle of 0 - 45 °and automatic tracking of the sun from East to West. They use the PV modules themselves as light sensor to avoid unnecessary tracking movement and for reliability. At night the trackers take up a horizontal position.

DUAL AXIS TRACKERS
Double axis solar trackers have both a horizontal and a vertical axle and so can track the Sun's apparent motion exactly anywhere in the world. This type of system is used to

control astronomical telescopes, and so there is plenty of software available to automatically predict and track the motion of the sun across the sky. Dual axis trackers track the sun both East to West and North to South for added power output (approx 40% gain) and convenience.

II. LITERATURE RESEARCH

This chapter aims to provide a brief knowledge of Solar Panel, Solar Tracker and the components which made up Solar Tracker.

2.1 Technology of Solar Panel

Solar panels are devices that convert light into electricity. They are called solar after the sun because the sun is the most powerful source of the light available for use. They are sometimes called photovoltaic which means "light-electricity". Solar cells or PV cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charge layers. A solar panel is a collection of solar cells. Although each solar cell provides a relatively small amount of power, many solar cells spread over a large area can provide enough power to be useful. To get the most power, solar panels have to be pointed directly at the Sun. The development of solar cell technology begins with 1839 research of French physicist Antoine-Cesar Becquerel. He observed the photovoltaic effect while experimenting with a solid electrode in an electrolyte solution. After that he saw a voltage developed when light fell upon the electrode. According to Encyclopaedia Britannica the first genuine for solar panel was built around 1883 by Charles Fritts. He used junctions formed by coating selenium (a semiconductor) with an extremely thin layer of gold. Crystalline silicon and gallium arsenide are typical choices of materials for solar panels. Gallium arsenide crystals are grown especially for photovoltaic use, but silicon crystals are available in less-expensive standard ingots, which are produced mainly for consumption in the microelectronics industry. Norway"s Renewable Energy Corporation has confirmed that it will build a solar manufacturing plant in Singapore by 2010 - the largest in the world. This plant will be able to produce products that can generate up to 1.5 Giga watts of energy every year. That is enough to power several million households at any one time. Last year the world as a whole produced products that could generate just 2 GW in total. The increasing energy demands have forced the researchers to concentrate over renewable energy with environment friendly nature. Our Sun emits enormous amount of heat and light energy which will continue to exist for at least another billion years, so effective collection of the solar energy stands as an opportunity and a challenge. Various works are carried out with photo voltaic panels to increase the rate of energy collection. The flat plate solar collectors, depending on the conditions of the sky, absorb maximum amount of global solar irradiance especially around midday, when the solar beam radiation takes its maximum values. Haung and Sun designed a single axis three positions tracking system. Theoretical results based on radiation predicted on clear sky conditions showed that the optimal stopping angle of the panel during morning and afternoon was about 50˚ from noon position, independent of the site latitude. A study performed by Morcos showed that changing collectors' azimuth and tilt angles daily to their optimum values resulted in an increase in total solar radiation compared with a fixed collector with the tilt-angle equal to its geographic latitude. A feasible approach for maximizing the efficiency of solar array system is sun tracking. The extra benefits from tracking the sun were about 20-40% of output power compared to that of fixed panel. Dual-axis tracked panels performed best in term of the solar gain, but a complicated tracking system was required. Thus, single-axis tracking systems were technically and economically more attractive in practical applications of non - concentrating solar devices. Energy generation from photovoltaic (PV) technology is simple, reliable, available everywhere, long lasting, almost maintenance free, clean, suitable for off-grid applications, and to certain extent has become affordable in the recent times. This type of energy has experienced a rapid growth due to environmental awareness and adverse effects of climate change on the human life. The analysis presented the effect of PV surface temperature and dust collected on the panels on the power output of individual arrays and total power from complete plant. Furthermore, the PV panel performance was studied by DC (Direct current) performance ratio variation with PV panel backside surface temperature. A solar tracking system is a control system that consists of several sensors that check whether the sunlight is perpendicular to the PV panel or not, and a controller that give signals to one or more actuator to move the panel to the right position. The controller aims at maximizing the solar PV cell's efficiency by forcing sunlight to be incident perpendicularly to the PV panel at all times. The system consists of PV solar panel that is allowed to move using two motors, four PV sensors positioned at four different locations, and a fuzzy logic controller that takes the inputs from the four sensors and calculates the appropriate output speeds for both motors. The objective of this work is to investigate the optical performance of solar panels tracking the sun about a horizontal axis with an automatic solar tracking system from east to west orientation by using light dependent resistor (LDR) and compare with fixed panels based on monthly horizontal radiation data.

2.2 Evolution of Solar Tracker

Since the sun moves across the sky throughout the day, in order to receive the best angle of exposure to sunlight for collection energy. A tracking mechanism is often incorporated into the solar arrays to keep the array pointed towards the sun. A solar tracker is 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. When compare to the price of the PV solar panels, the cost of a solar tracker is relatively low. Most photovoltaic solar panels are fitted in a fixed location- for example on the sloping roof of a house, or on framework fixed to the ground. Since the sun moves across the sky though the day, this is far from an ideal solution. Solar panels are usually set up to be in full direct sunshine at the middle of the day facing South in 4info4eee | Information For Electrical & Electronics Engineering the Northern Hemisphere, or North in the Southern Hemisphere. Therefore morning and evening sunlight hits the panels at an acute angle reducing the total amount of electricity which can be generated each.

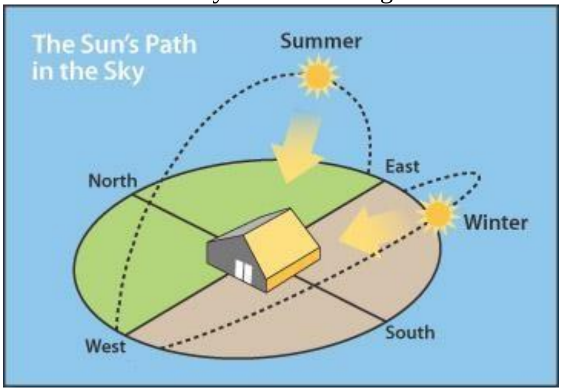

Figure 2.1 Sun's apparent motion as seen from the Northern Hemisphere

During the day the sun appears to move across the sky from left to right and up and down above the horizon from sunrise to noon to sunset. Figure 2.1 shows the schematic above of the Sun's apparent motion as seen from the Northern Hemisphere. To keep up with other green energies, the solar cell market has to be as efficient as possible in order not to lose market shares on the global energy marketplace.

The end-user will prefer the tracking solution rather than a fixed ground system to increase their earnings because:

- The efficiency increases by 30-40%.
- The space requirement for a solar park is reduced, and they keep the same output.
- The return of the investment timeline is reduced.
- The tracking system amortizes itself within 4 years.
- In terms of cost per Watt of the completed solar system, it is usually cheaper to use a solar tracker and less solar panels where space and planning permit.
- A good solar tracker can typically lead to an increase in electricity generation capacity of 30-50%.

III. 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. The design and construction of it could be divided into six main parts that would need to work together harmoniously to achieve a smooth run for the Solar Tracker, each with their main function. They are:

- Methods of Tracker Mount
- Methods of Drives
- Sensor and Sensor Controller
- Motor and Motor Controller
- Tracker Solving Algorithm
- Data Acquisition/Interface Card

3.2 Methods of Tracker Mount

1. Single axis solar trackers
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.

2. Double axis solar trackers
Double axis solar trackers have both a horizontal and a vertical axle and so can track the Sun's apparent motion exactly anywhere in the World. This type of system is used to control astronomical telescopes, and so there is plenty of software available to automatically predict and track the motion of the sun across the sky. By tracking the sun, the efficiency of the solar panels can be increased by 30-40%.The dual axis tracking system is also used for concentrating a solar reflector toward the concentrator on heliostat systems.

3.3 Methods of Drive

1. Active Trackers
Active Trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Light-sensing trackers typically have two photo sensors, such as photodiodes, configured differentially so that they output a null when receiving the same light flux Mechanically, they should be omnidirectional 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.

2. Passive Trackers
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.
3.4 Sensors

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

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

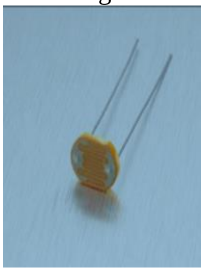

Figure 3.1 LDR Sensor

2. Photodiode

Photodiode is a light sensor which has a high speed and high sensitive silicon PIN photodiode in a miniature flat plastic package. A photodiode is designed to be responsive to optical input. Due to its water clear epoxy the device is sensitive to visible and infrared radiation. The large active area combined with a flat case gives a high sensitivity at a wide viewing angle. Photodiodes can be used in either zero bias or reverse bias. In zero bias, light falling on the diode causes a voltage to develop across the device, leading to a current in the forward bias direction. This is called the photovoltaic effect, and is the basis for solar cells - in fact a solar cell is just a large number of big, cheap photodiodes. Diodes usually have extremely high resistance when reverse biased. This resistance is reduced when light of an appropriate frequency shines on the junction. Hence, a reverse biased diode can be used as a detector by monitoring the current running through it. Circuits based on this effect are more sensitive to light than ones based on the photovoltaic effect.

Figure 3.2 Photodiode

3.5 Motor

Motor is use to drive the Solar Tracker to the best angle of exposure of light. For this section, we are using stepper motor.

Stepper Motor

Features

- 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

This application note describes how to implement an exact linear speed controller for stepper motors. 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. Many systems with stepper motors need to control the acceleration/deceleration when changing the speed. This application note presents a driver with a demo application, capable of controlling acceleration as well as position and speed.

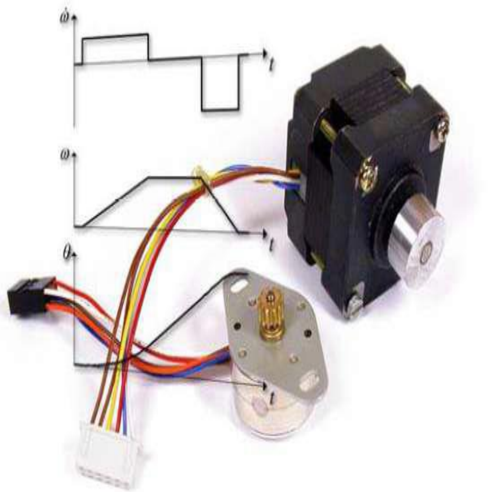

Figure 3.3 Stepper Motor

3.6 Microcontroller

A microcontroller is a single chip that contains the processor, non-volatile memory for the program, volatile memory for input and output, a clock and an I/O control unit also called a computer on a chip, billions of microcontroller units are embedded each year in a myriad of products from toys to appliances to automobiles. For example, a single vehicle can use 70 or more microcontrollers. The following picture describes a general block diagram of 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

High Endurance Non-volatile Memory segments

- 16K Bytes of In-System Self-programmable Flash program memory
- 512 Bytes EEPROM
- 1K Byte Internal SRAM
- Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
- Data retention: 20 years at 85°C/100 years at 25°C

Optional Boot Code Section with Independent Lock Bits

In-System Programming by On-chip Boot Program

True Read-While-Write Operation

- Programming Lock for Software Security.

3.7 LCD Display

A Liquid Crystal Display 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

Figure 3.4 LCD Display

3.8 Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors - the transformer's coils or windings. Except for air-core transformers, the conductors are commonly wound around a single iron-rich core, or around separate but magnetically coupled cores. A varying current in the first or primary winding creates a varying magnetic field in the core of the transformer. This varying magnetic field induces a varying electromotive force or voltage in the secondary winding. This effect is called mutual induction.

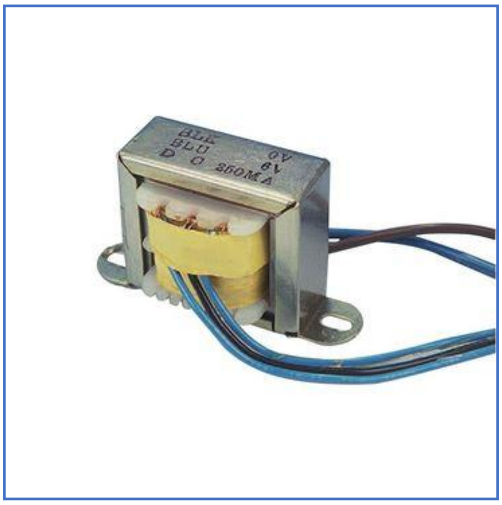

Figure 3.5 Transformer

3.8.1 Basic Parts of a Transformer

In its most basic form a transformer consists of:
- A primary coil or winding.
- A secondary coil or winding.
- A core that supports the coils or windings.

Refer to the transformer circuit in figure as you read the following explanation: The primary winding is connected to a 50-hertz ac voltage source. The magnetic field builds up and collapses about the primary winding. The expanding and contracting magnetic field around the primary winding cuts the secondary winding and induces an alternating voltage into the winding. This voltage causes alternating current to flow through the load. The voltage may be stepped up or down depending on the design of the primary and secondary windings.

3.8.2 The Components of a Transformer

Two coils of wire are wound on some type of core material. In some cases the coils of wire are wound on a cylindrical or rectangular cardboard form. In effect, the core material is air and the transformer is called an air-core transformer. Transformers used at low frequencies, such as 50 hertz and 400 hertz, require a core of low-reluctance magnetic material, usually iron. This type of transformer is called an iron-core transformer.

Most power transformers are of the iron-core type. The principle parts of a transformer and their functions are: The core, which provides a path for the magnetic lines of flux. The Primary winding, this receives energy from the ac source. The secondary winding, this receives energy from the primary winding and delivers it to the load. The enclosure, this protects the above components from dirt, moisture, and mechanical damage.

3.9 Bridge Rectifier

A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.

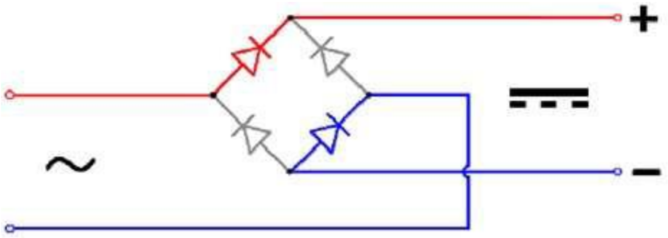

Figure 3.6 Bridge Rectifier

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 3.7 Light Emitting Diode

3.11 Resistor

A resistor is a component of a circuit that resists the flow of electrical current. It has two terminals across which electricity must pass, and it is designed to drop the voltage of the current as it flows from one terminal to the other. Resistors are primarily used to create and maintain known safe currents within electrical components. Resistance is measured in ohms, after Ohm's law. This law states that electrical resistance is equal to the drop in voltage across the terminals of the resistor divided by the current being applied. A high ohm rating indicates a high resistance to current. This rating can be written in a number of different ways - for example, 81R represents 81 ohms, while 81K represents 81,000 ohms. Materials in general have a characteristic behavior of opposing the flow of electric charge. This opposition is due to the collisions between electrons that make up the materials. This physical property, or ability to resist current, is known as resistance and is represented by the symbol R. Resistance is expressed in ohms which is symbolized by the capital Greek letter omega.

The resistance of any material is dictated by four factors:

- Material property-each material will oppose the flow of current differently.
- Length-the longer the length, the more is the probability of collisions and, hence, the larger the resistance.
- Cross-sectional area-the larger the area A, the easier it becomes for electrons to flow and, hence, the lower the resistance.
- Temperature-typically, for metals, as temperature increases, the resistance increases.

The amount of resistance offered by a resistor is determined by its physical construction. A carbon composition resistor has resistive carbon packed into a ceramic cylinder, while a carbon film resistor consists of a similar ceramic tube, but has conductive carbon film wrapped around the outside. Metal film or metal oxide resistors are made much the same way, but with metal instead of carbon. A wire wound resistor, made with metal wire wrapped around clay, plastic, or fibre glass tubing, offers resistance at higher power levels. Those used for applications that must withstand high temperatures are typically made of materials such as cermets, a ceramic-metal composite, or tantalum, a rare metal, so that they can endure the heat. Resistors are coated with paint or enamel, or covered in moulded plastic to protect them. Because they are often too small to be written on, a standardized color-coding system is used to identify them. The first three colors represent ohm value, and a fourth indicates the tolerance, or how close by percentage the resistor is to its ohm value. This is important for two reasons: the nature of its construction is imprecise, and if used above its maximum current, the value can change or the unit itself can burn up. The circuit element used to model the current-resisting behavior of a material is the resistor. For the purpose of constructing circuits, resistors shown in figure are usually made from metallic alloys and carbon compounds. The resistor is the simplest passive element.

Figure 3.8 Resistor

IV . WORKING PRINCIPLE OF THE TRACKER

It is the one which follows the sun’s movement through out the day and provides uninterrupted reflection to the solar panel. The sun rays will fall on the solar panel in two ways, which is, they will fall directly on the solar panel and also the reflector will reflect the incident rays on the solar panel. Suppose at the time of sun rise the sun is in extreme east the reflector will align itself in some position by which the incident rays will fall on the solar panel. Now when the earth rotates and the sun gets shifted form its earlier position the reflection of the incident rays will also change. Thus as a result the light will fall on the sensors kept on each side of the solar panel. The tracking circuit is so designed that when reflection falls on say the sensor attached to the right of the panel, the tracker will move towards the left, and visa-versa. Similar is the case when the reflection falls on the sensor attached at the top of the panel, circuit will make the tracker to move downwards. We here have tried to bring two simple principles together. One being, the normal principle of incidence and reflection on which our tracker works. And the other is the principle on which the solar panel works, which is on the incidence of the solar rays the photovoltaic cells, will produce electricity. This both principles are combined there and as a result of which we are able to fetch nearly double the output which the panel gives normally. Precisely speaking the tracker is liable for two kinds of rotations, on is on the vertical axis and other is on the horizontal axis. The earlier is for the right-left movement of the reflection and the later is for the up-down movement of the reflector, for aligning reflection on the panel.

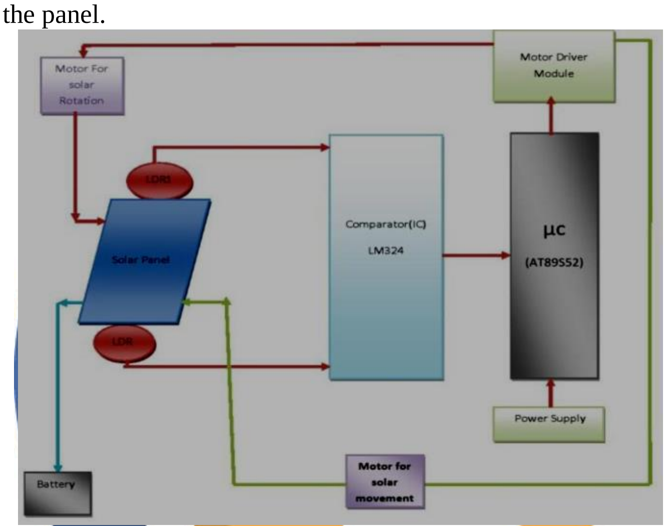

Figure 4.1 Working Principle of Solar Tracker

V . AUTOMATIC SOLAR TRACKER COMPONENTS DESCRIPTION

The major part of this electronics system is the micro controller. All the operations are controlled by it. With the help of micro controller, you can align the solar panel according to the intensity of the sunlight. Another component is the rechargeable battery which is used to store energy which is received from the panel. The purpose of the charge control is to control the charging of the battery. Micro controller unit receives the status of the battery by the charge control unit. It has two sensors, each made up of LDR. Four LDRs constitute on unit and are placed at the four corners of the panel. LDR senses the intensity of sunlight and controller receives the output. Control unit decides in which direction the panel has to be rotated to get maximum sunlight. Another unit of the sensor also consists of LDRs and used for the control of lightning load. The panel can be rotated in the desired direction by the server motor.

5.1 Circuit Diagram

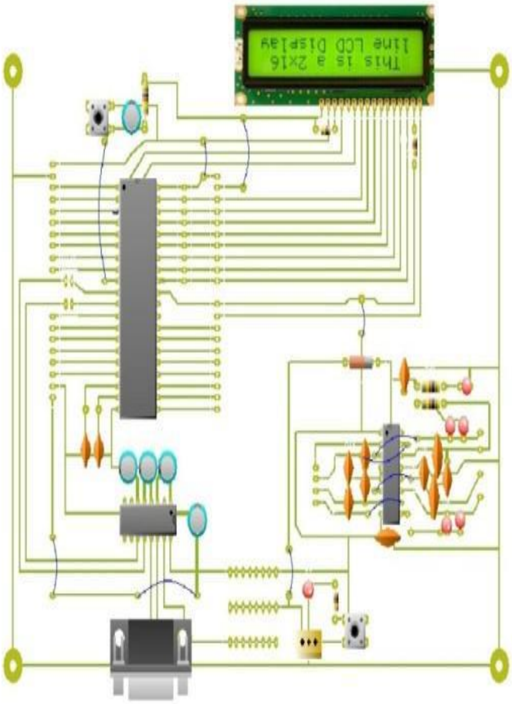

Figure 5.1 Circuit Diagram

5.2 Component Required

Table 5.1 Components Required

Sr. Number	Component Name	Component Description	Number of Quantity
1	LDR Sensor		2
2	Diode	IN4007 (d1)	1
3	LED	3mm(1.5V & 20mA)	8
4	Electrolytic Capacitors	1000µF,10 µF(c4,c7,c6,c8)	1,4
5	Ceramic Capacitors	33pf(c1,c2)	2
6	Multilayer Capacitors	0.1 µF (c5, c9, c10, c11, c12, c13, c14, c15, c16,c17)	10
7	Resister	220Ω (r4,r3,r2,r1,r10,r39,r38)	7
8	Variable resistor	20k	2
9	Resistor Array	10k(RN2)	1
10	push to on off Switch	6 Pin (s1,S2)	2
11	Reset Switch	4 Pin(s1)	1
12	Crystal oscillator	11.0592Mhz (q1)	1
13	LCD	16*2	1
14	Voltage regulator	7805 IC	1
15	Max232 IC	14 Pin(IC3)	1
16	LM293D IC	14 Pin(IC2)	1
17	(Atmel -AT89S52) IC	40 Pin (IC1)	1
18	Female Connector	Db9	1
19	Male & Female Berg Stick	Long Strips of Both	3
20	Lead acid Battery	6 volts	1
21	Solar Panel	3 watts	1
22	Motor	12 volts, 10 rpm	1
23	Wire	5m	2

VI . BLOCK DIAGRAM

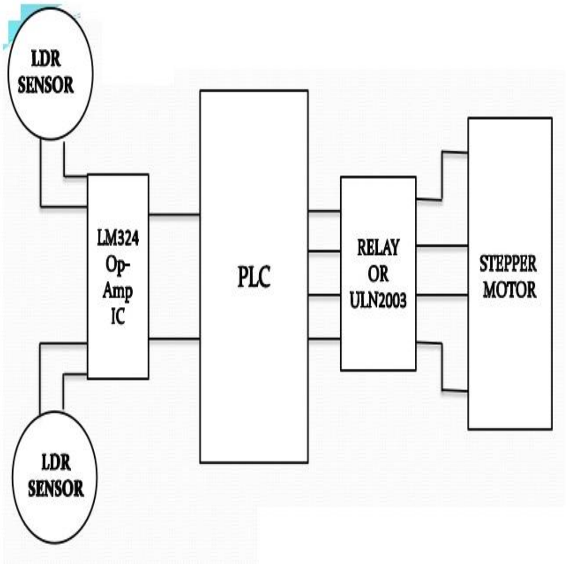

Figure 6.1 Circuit of PLC Block Diagram

6.1 Block Diagram Description

MICROCONTROLLER
It is the major part of the system. The microcontroller controls all the operations. The solar panel is aligned according to the intensity of sunlight under the control of the microcontroller.

SENSOR
The system consists of two sensors, each composed of LDR. One unit is made up of four LDRs. These are placed at the four corners of the solar panel. The intensity of sunlight is sensed by the LDR and the output is sent to the controller. The control unit analyzes it and decides the direction in which the panel has to be rotated, so that it gets maximum intensity of light.
The other unit of sensor is also composed of LDRs which is meant for the control of a lighting load.

SERVO MOTOR
Servo motor is used to rotate the panel in desired direction. It is controlled by the controller.

SOLAR PANEL
Solar panel is used for the conversion of solar energy directly into electricity. It is composed of photo voltaic cells, which convert solar energy into electrical energy.

CHARGE CONTROL
It is meant to control the charging of battery. It sends the status of battery to the microcontroller unit.

BATTERY
It is for the storage of energy received from the panel. A rechargeable battery is normally employed for this purpose.

Figure 6.2 Solar Tracking Devices

VII.RESULTS AND DISCUSSIONS

In view of the received amount of solar energy for different sky conditions, the average value of output power of both tracking system and fixed system for clear sky, partially clear sky and cloudy sky. For clear sky days throughout the day length tracking system have shown comparatively higher performance than fixed tilt system. The graph indicates that the power output of fixed tilt panel gradually decreases with time, while for tracking system the power output marginally decreases with time due to decrease in intensity of solar radiation. Similar results are obtained for average clear sky days with marginally lower average output than that of clear sky days for both sun tracking system and fixed tilt system. This indicates that automatic sun tracking system boosts the energy collection of photo voltaic panel. It is observed from the daily amounts of produced electrical energy, that the increase in solar gain for East-West tracking system as compared to fixed tilt system strongly depends on climatic conditions of the location. On cloudy days the daily collected direct solar irradiance is very small. Mainly diffused radiation and reflected radiations provide little power generation from the photo voltaic panel. Comparatively low power output was recorded on cloudy days. Hence use of automatic sun tracking system is unnecessary during cloudy days.

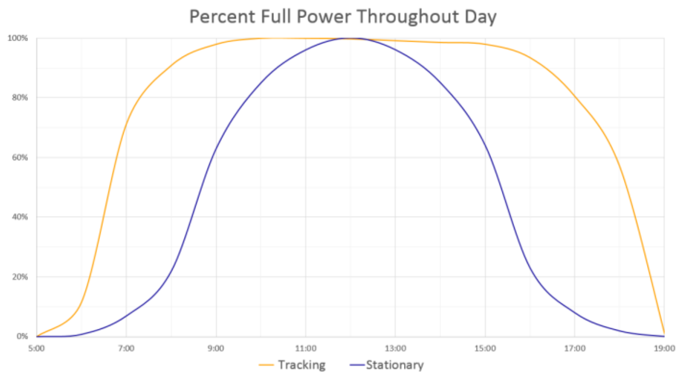

Figure 7.1 Percent Full Power Througout Day

CONCLUSION

In this thesis, the sun tracking system was implemented which is based on PIC microcontroller. After examining the information obtained in the data analysis section, it can be said that the proposed sun tracking solar array system is a feasible method of maximizing the energy received from solar radiation. The controller circuit used to implement this system has been designed with a minimal number of components and has been integrated onto a single PCB for simple assembly. The use of stepper motors enables accurate tracking of the sun while keeping track of the array's current position in relation to its initial position. The automatic solar radiation tracker is an efficient system for solar energy collection. It has been shown that the sun tracking systems can collect about 8% more energy than what a fixed panel system collects and thus high efficiency is achieved through this tracker. 8% increase in efficiency is not the most significant figure; it can be more prominent in concentrating type reflectors.

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