Department of Computer Science and Engineering

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A Seminar project report

On

ARDUINO BASED SOLAR TRACKING SYSTEM

Submitted By

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1. Introduction

(i) Purpose

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Thus to get a constant output, an automated system is required which should be capable to constantly rotate the solar panel. The Sun Tracking System (STS) was made as a prototype to solve the problem, mentioned above. It is completely automatic and keeps the panel in front of sun until that is visible. The unique feature of this system is that instead of taking the earth as its reference, it takes the sun as a guiding source. Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum. With the rapid increase in population and economic development, the problems of the energy crisis and global warming effects are today a cause for increasing concern. The utilization of renewable OPEN ACCESS Sensors 2013, 13 3158 energy resources is the key solution to these problems. Solar energy is one of the primary sources of clean, abundant and inexhaustible energy, that not only provides alternative energy resources, but also improves environmental pollution. The most immediate and technologically attractive use of solar energy is through photovoltaic conversion. The physics of the PV cell (also called solar cell) is very similar to the classical p-n junction diode. The PV cell converts the sunlight directly into direct current (DC) electricity by the photovoltaic effect [1,2]. A PV panel or module is a packaged interconnected assembly of PV cells. In order to maximize the power output from the PV panels, one needs to keep the panels in an optimum position perpendicular to the solar radiation during the day. As such, it is necessary to have it equipped with a Sun tracker. Compared to a fixed panel, a mobile PV panel driven by a Sun tracker may boost consistently the energy gain of the PV panel

(ii) Scope

- It can be used for small and medium scale power generations.
- It can be used for power generation at remote places where power lines are not accessible.
- It can be used for domestic and industrial power backup sytem.
- Solar radiation Tracker has played a vital role in increasing the efficiency of solar panels in recent years, thus proving to be a better technological achievement. The vital importance of a dual axis solar tracker lies in its better efficiency and sustainability to give a better output compared to a fived solar panel or a single axis solar tracker. The tracking system is designed such that it can trap the solar energy in all possible directions

(iii) Definition

A Solar tracker is an automated solar panel which actually follows the sun to get maximum power. The primary benefit of a tracking system is to collect solar energy for the longest period of the day, and with the most accurate alignment as the Sun's position shifts with the seasons.Dual Axis Tracker have two different degrees through which they use as axis of rotation. The dual axis are usually at a normal of each rotate both east to west (zenithal) and north to south. Solar tracking is the most appropriate technology to enhance the electricity production of a PV system. To achieve a high degree of tracking accuracy, several approaches have been widely investigated. Generally, they can be classified as either open-loop tracking types based on solar movement mathematical models or closed-loop tracking types using sensor-based feedback controllers [3–5]. In the open-loop tracking approach, a tracking formula or control algorithm is used. Referring to the literature [6–10], the azimuth and the elevation angles of the Sun were determined by solar movement models or algorithms at the given date, time and geographical information. The control algorithms were executed in a microprocessor controller [11,12]. In the closed-loop tracking approach, various active sensor devices, such as charge couple devices (CCDs) [13–15] or light dependent resistors (LDRs) [12,16–19] were utilized to sense the Sun's position and a feedback error signal was then generated to the control system to continuously receive the maximum solar radiation on the PV panel. This paper proposes an empirical research approach on this issue. Solar tracking approaches can be implemented by using single-axis schemes [12,19–21], and dual-axis structures for higher accuracy systems [16–18,22–27]. In general, the single-axis tracker with one degree of freedom follows the Sun's movement from the east to west during a day while a dual-axis tracker also follows the elevation angle of the Sun. In recent years, there has been a growing volume of research concerned with dual-axis solar tracking systems. However, in the existing research, most of them used two stepper motors [22,23] or two DC motors [16,17,24,25] to perform dual-axis solar tracking. With two tracking motors designs, two motors were mounted on perpendicular axes, and even aligned them in certain directions. In some cases, both motors could not move at the same time [5]. Furthermore, such systems always involve complex tracking strategies using microprocessor chips as a control platform. In this work, employing a dual-axis with only single tracking motor, an attempt has been made to develop and implement a simple and efficient control scheme. The two axes of the Sun tracker were allowed to move simultaneously within their respective ranges. Utilizing conventional electronic circuits, no programming or computer interface was needed. Moreover, the proposed system used a stand-alone PV inverter to drive motor and provide power supply. The system was self-contained and autonomous. Experiment results have demonstrated the feasibility of the tracking PV system and verified the advantages of the proposed control implementation.

2.Overall Description

(i) Product Perspective

a) System Interface

ATmega328p Microcontroller:-The high-performance Microchip picoPower 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

b) User Interface

It should be the connector between the various systems and the system or between other parts or unit of the system.

c) Hardware Interface

Solar Panel:-

Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. Photovoltaic modules use light energy (photons) from the

Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones are available, based on thin-film cells. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weatherproof connections to the rest of the system.

Modules electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated.

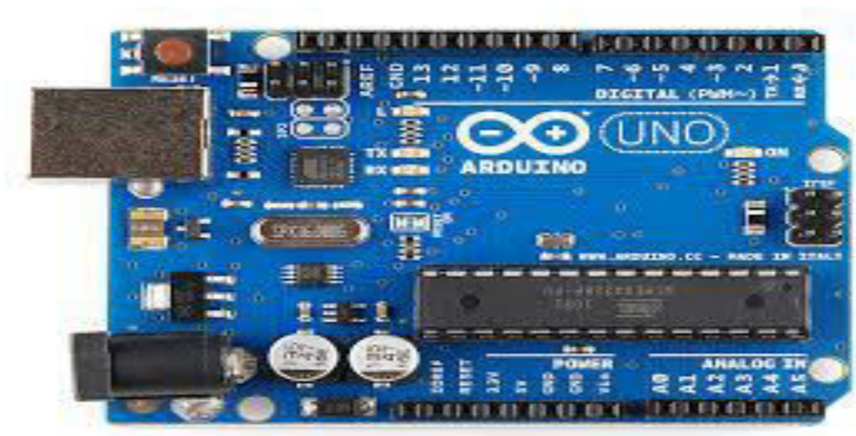
Arduino UNO Microcontroller :-

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public

License (GPL) permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

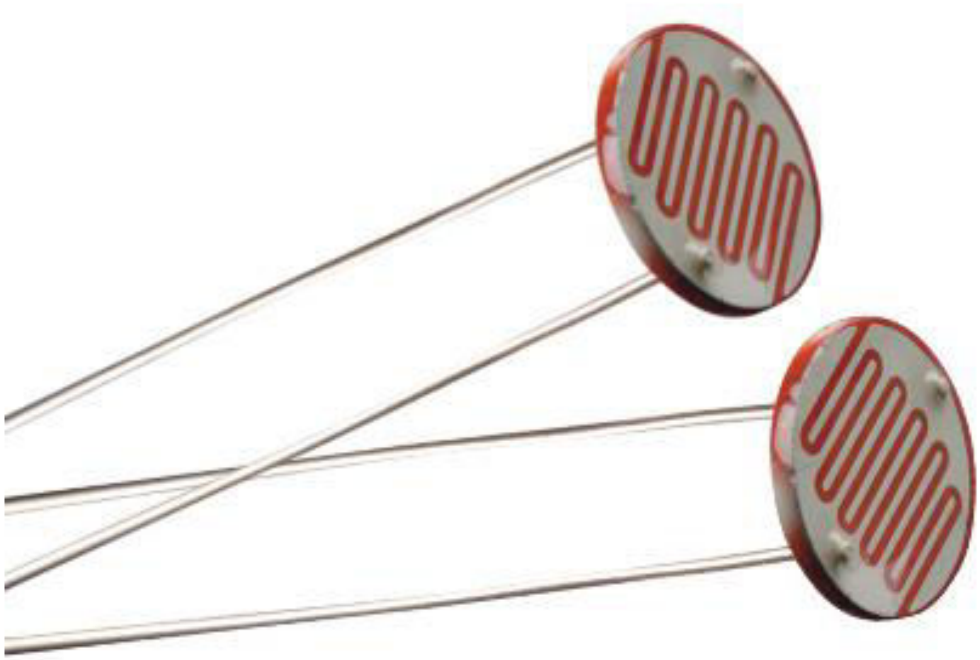
Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (*shields*) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

Arduino/Genuino Uno:- is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.



LDRs :-

A **Light Dependent Resistor** (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. A photoresistor is made of a high resistance semiconductor. In the dark, a photoresistor can have a resistance as high as several megohms (MΩ), while in the light, a photoresistor can have a resistance as low as a few hundred ohms. If incident light on a photoresistor exceeds a certain frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electrons (and their hole partners) conduct electricity, thereby lowering resistance. The resistance range and sensitivity of a photoresistor can substantially differ among dissimilar devices. Moreover, unique photoresistors may react substantially differently to photons within certain wavelength bands.



Servo Motors:-

A **servomotor** is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Servomotors are not a specific class of motor although the term *servomotor* is often used to refer to a motor suitable for use in a closed-loop control system.

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft.

The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

The very simplest servomotors use position-only sensing via a potentiometer and bang-bang control of their motor; the motor always rotates at full speed (or is stopped). This type of servomotor is not widely used in industrial motion control, but it forms the basis of the simple and cheap servos used for radio-controlled models.

More sophisticated servomotors use optical rotary encoders to measure the speed of the output shaft and a variable-speed drive to control the motor speed. Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.

d) Software Interface

Arduino IDE:-

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio

. The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages *Processing* and *Wiring*. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple *one-click* mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.

A program written with the IDE for Arduino is called a *sketch*. Sketches are saved on the development computer as text files with the file extension *.ino*. Arduino Software (IDE) pre-1.0 saved sketches with the extension *.pde*.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

e) Communication Interface:-

NIL

f) Memory Requirement:-

NIL

g) Operation

1. LDRs are used as the main light sensors. Two servo motors are fixed to the structure that holds the solar panel. The program for Arduino is uploaded to the microcontroller. The working of the project is as follows.

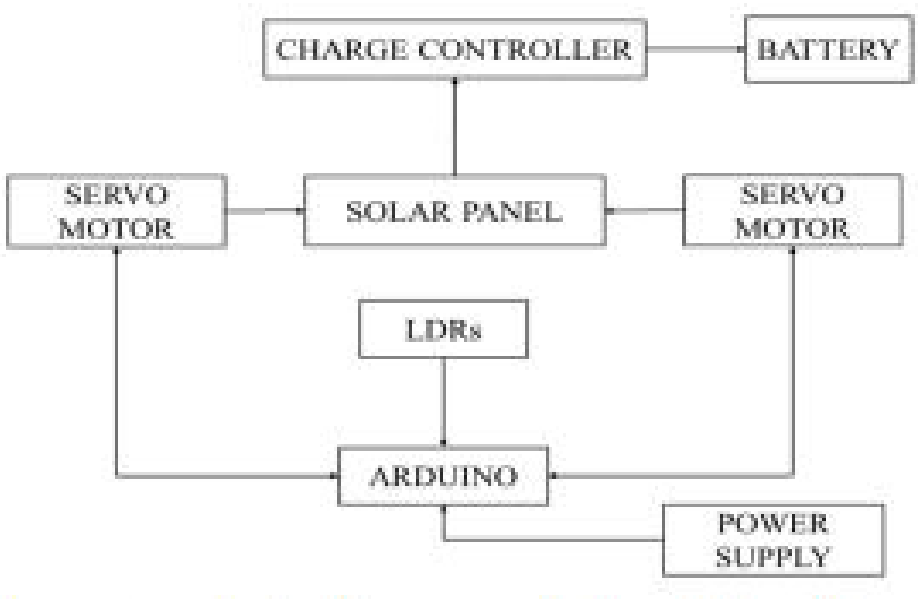
2. LDRs sense the amount of sunlight falling on them. Four LDRs are divided into top, bottom, left and right.

3. For east – west tracking, the analog values from two top LDRs and two bottom LDRs are compared and if the top set of LDRs receive more light, the vertical servo will move in that direction.

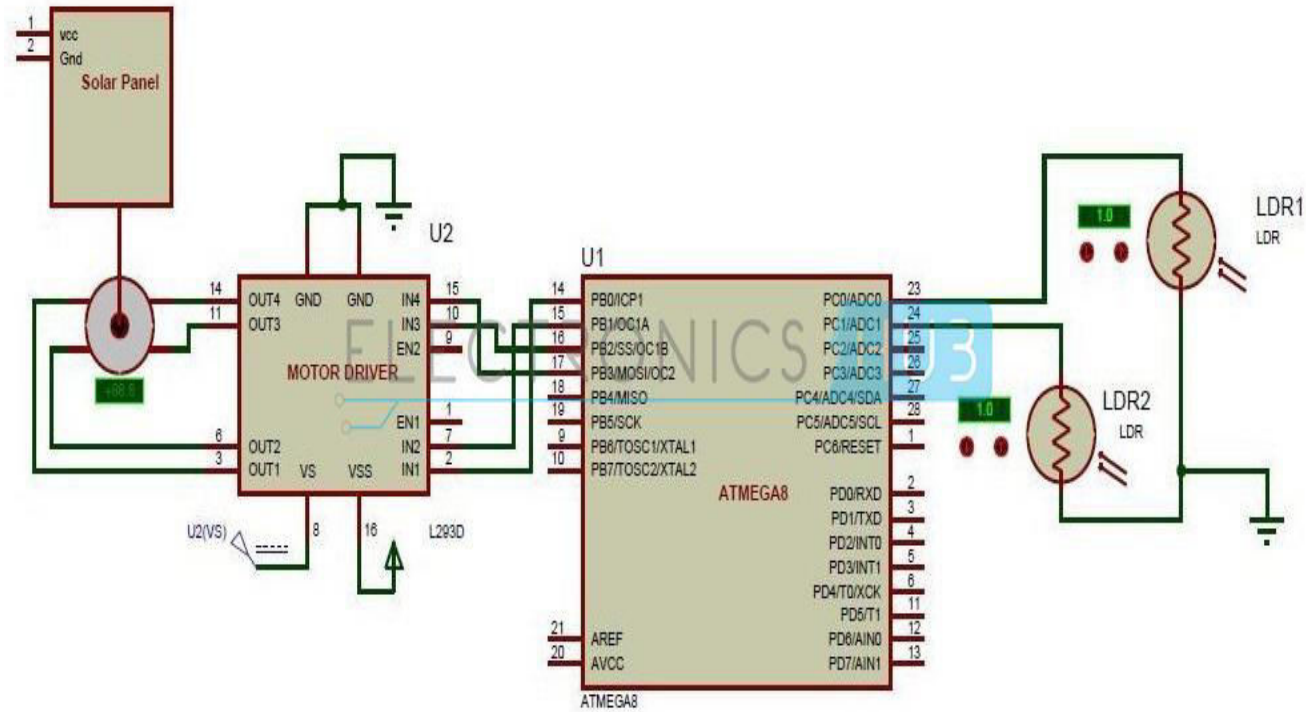
4. If the bottom LDRs receive more light, the servo moves in that direction.

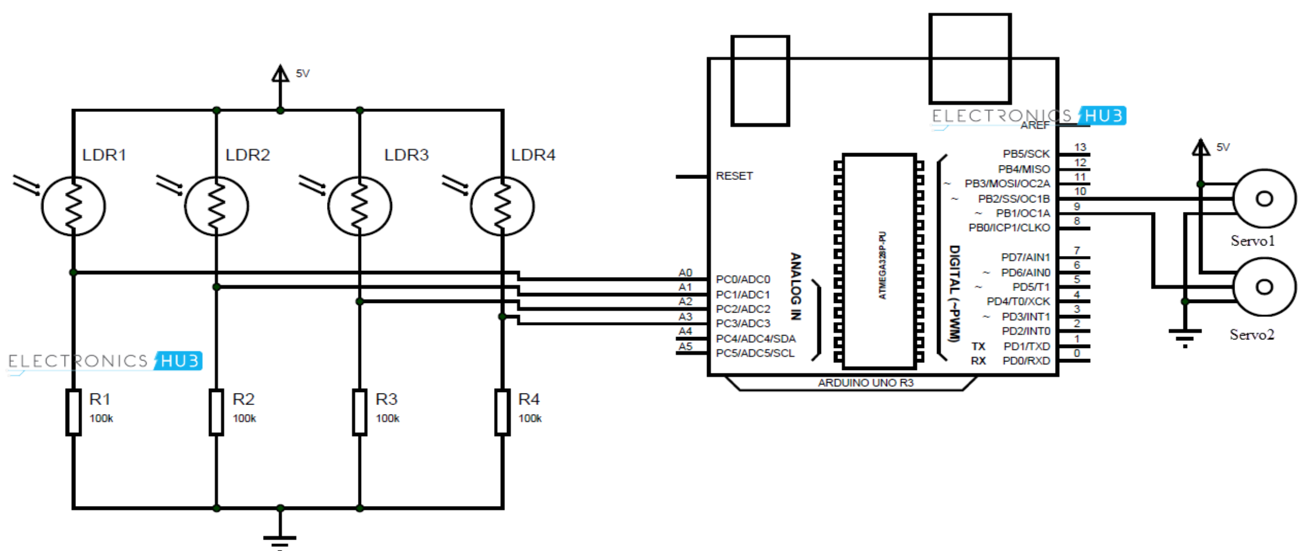
5. For angular deflection of the solar panel, the analog values from two left LDRs and two right LDRs are compared. If the left set of LDRs receive more light than the right set, the horizontal servo will move in that direction.

6. If the right set of LDRs receive more light, the servo moves in that direction.



Block diagram of arduino based sun solar tracking system





pin diagram of arduino based sun solar tracking system

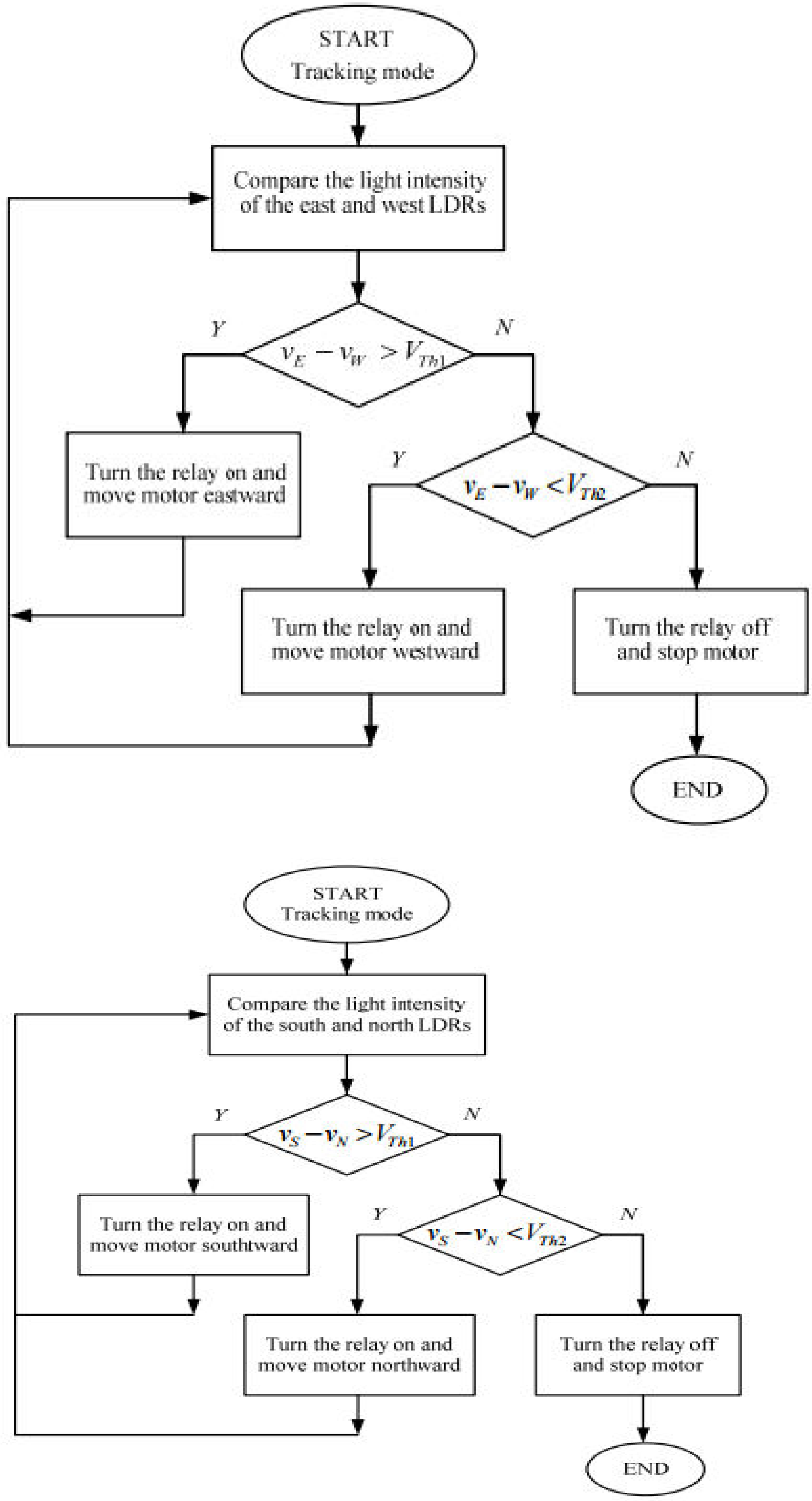
h) Site Adaptation Requirement

NIL

(ii) Product Functions

Algorithm –
Step1: Start
Step2: Initialise all necessary inputs and outputs to zero.
Step3: Assign analog LDR outputs and PWM servomotor inputs to Arduino Uno.
Step4: If centre LDR = 0, then delay (longer).
Step5: Check alignment (Simultaneously for northsouth and east-west)
Step6: If up (LDR) greater than centre and down (LDR) lesser than centre, then increase position of servomotor1 by 1 unit. Give delay.
Step7: Else if up (LDR) lesser than centre and down (LDR) greater than centre, then decrease position of servomotor1 by 1 unit. Give delay.
Step8: (Simultaneously along with step6) If right (LDR) greater than centre and left (LDR) lesser than centre then increase the position of servomotor2 by 1 unit. Give delay.

Step9: Else if right (LDR) is lesser than centre and left (LDR) greater than centre then decrease position of servomotor2 by 1 unit. Give delay.
Step10: Goto Step 5.
Step11: End.



Flowchart of tracking algorithm for azimuth control and elevation control.

(iii) User Characteristics

No particular requirement

(iv) Constraints

- Higher mechanical complexity, making it more likely for something to go wrong
- Lower lifespan and lower reliability
- Unreliable performance in cloudy or overcast weather

(v) Assumption & Dependencies

- All the soldering and wiring are done correctly.
- There must be a sunny day for the full efficiency of the system.

3.Specific Requirement

(i) External Interface Requirement

(a) Hardware Interface Requirement

Solar Panel:-**Solar panel** refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating.

Arduino UNO Microcontoller:-

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(b) Software Interface Requirement

Arduino IDE:-

The Arduino IDE is a cross-platform Java application that serves as a code editor and compiler and is also capable of transferring firmware serially to the board.

The development environment is based on Processing, an IDE designed to introduce programming to artists unfamiliar with software development. The programming language is derived from Wiring, a C-like language that provides similar functionality for a more tightly restricted board design, whose IDE is also based on Processing.

(c) Communication Interface Requirement

NIL

(ii) Product Feature

The unique feature of this system is that instead of taking the earth as its reference, it takes the sun as a guiding source. Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum.

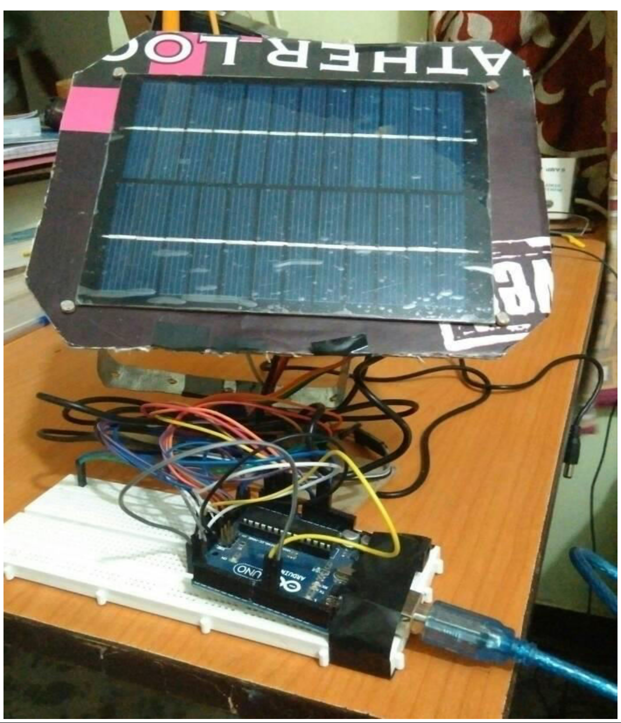
(iii) Performance Requirement

There must be a sunny day for the full efficiency of the system

(iv)Design Constraint

- Higher mechanical complexity, making it more likely for something to go wrong
- Lower lifespan and lower reliability
- Unreliable performance in cloudy or overcast weath.

4.Screen Shot:-



5.Conclusion:-

As dual-axis tracking generates 40% more power from each panel, you can achieve the same power output with fewer panels, frames and so on, which reduces a project's upfront costs and offsets to a great extent the additional cost for tracking hardware. On the other hand, you can use the same number of panels as originally planned and generate 40% more power and higher revenues. This reduces the project's payback time and also increases the overall return on investment (ROI), depending on the financial specifics of the project.

Solar radiation Tracker has played a vital role in increasing the efficiency of solar panels in recent years, thus proving to be a better technological achievement. The vital importance of a dual axis solar tracker lies in its better efficiency and sustainability to give a better output compared to a fived solar panel or a single axis solar tracker. The tracking system is designed such that it can trap the solar energy in all possible directions. Generally, in a single axis tracker that moves only along a single axis it is not possible to track the maximum solar energy. In case of dual axis trackers, if the solar rays are perpendicular to panel throughout the year. Hence, maximum possible energy is trapped throughout the day as well as throughout the year. Thus, the output increases indicating that the efficiency more than a fixed solar panel (about 30 -40% more) or a single axis solar tracker (about 6-7% more).