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# Design of Solar Charged Tracking Power Supply

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**Abstract**—*Sun energy is the future which will cover all the needs of mankind, as the non-renewable resources are depleting at a fast rate. This paper deals with the design of a solar charged tracker which works on the light intensity of the sun and extracts both its components diffused and direct. Single axis solar tracker is covered along with the future scope for a dual axis having dc geared motors, microcontroller, LDR along with the panel. The design is implemented with the use software viz. AVR studio and AVR dude .From the study it is found that the dc motors rotate the panel when the light falls on the sensor.*

## 1. INTRODUCTION

The growth rate of every country is increasing day by day with the rising demands, as a result non-renewable resources of energy are depleting at a rapid rate. So, there is a need to develop the techniques and technologies which can replenish the renewable source of energy. Sun or solar energy is the one which is present enormously. Only it requires the right use of technology to convert it into one form of energy into other.

The sun apparent position changes according to seasons along with the day and night. Azimuth angle covers the east and west direction while zenith angle covers the north and south i.e. the latitude of the sun. The solar tracker should be such that it should cover these two angles and efficient solar rays fall on the panel. In a dual axis solar tracker it is possible to generate 40% energy as compared to a fixed solar tracker [1].There are different types of solar positioning systems like closed, open and hybrid. While the open loop system is based on the mathematical model, closed loop system is based on the feedback control of the controller and the sensors. Operating principles for both consists of photosensitive element.

GPS, computer hardware along with the complex mechanical structure is needed for the open loop system which is costly. A complex system requires the measurement of azimuthal and zenith angle hence sensor calibration is needed. The design of open loop system is simple compared to closed loop. In closed loop systems positioning error along with disturbances are faced due to sensitivity of the controller.

PV systems are used for increasing the efficiency of the solar tracker. The three major methods for increasing the efficiency involves: generating more efficiency in the solar cells, second is maximum power point tracking (MPPT) algorithms, third is to build a sensitive controlled solar tracking system which can extract more sun intensity [2].

## 2. SOLAR TRACKING SYSTEM

Sun tracking can be done in the two axes, one is horizontal tracking in which the east and west direction of the sun position is tracked. While in the other the north and south i.e. the height of the sun is also tracked this is known as vertical tracking.

Sun tracking systems use the motor for moving the panel assembly according to the signals received from the light sensors. Tracking control principles can be classified into microcontroller control unit, passive control unit and electro-optical control unit [7].Microcontroller control unit is more accurate as there is no electronic control unit in the passive. In electro-optical control unit photo-sensors are placed on PV panels which are sensitive to light and controls the panel according to the intensity of light falls on them.

PV systems will be the future for generating the energy from the renewable source .Both in northern and southern hemisphere solar panels are placed in the middle of sunshine so that in morning and in evening the sun rays falls on the panel at an acute angle thereby more energy is generated and the losses are less.

## 3. DESIGN AND COMPONENTS FOR SOLAR TRACKER

The design of solar tracker needs the study of various components used involving the electronic and the mechanical part and then to integrate them for designing an accurate tracker. The electronic part design consists of the suitable selection of the microcontroller which can be integrated to peripherals and can be modeled according to use. DC motors should hold the payload to which shaft is connected which rotates the panel assembly. LDR or sensors should be sensitive enough to get the slight deviation in the sun rays and changes the signal accordingly. Along with these there are various factors like: cost, reliability, material and structural design, efficiency of circuit design along with the positioning of the sensors play the vital role in the design of the solar tracker system. To build an efficient tracker it requires an algorithm.

## 4. ALGORITHM

The algorithm used in the solar tracker is based on the intensity of the sun rays. A pair of sensor is used for the east and west and for the dual axes as well.

At first the light intensity is sensed by the LDR then the voltage comparator IC compares the intensity with that of threshold and if greater than that it sends the output to the microcontroller which then drives the motor 1 which is responsible for the east and west i.e. horizontal axis tracking .If the threshold value is below then the light intensity from the second sensor is sensed and if it is greater than the same procedure is followed and the microcontroller control unit drives the motor 2 which is responsible for the north and south i.e. vertical axis tracking. And if both values of sensors are below the threshold, then both motors will be off. The value of light intensity can be set by using the potentiometers as per requirement.

### BLOCK DIAGRAM OF SYSTEM

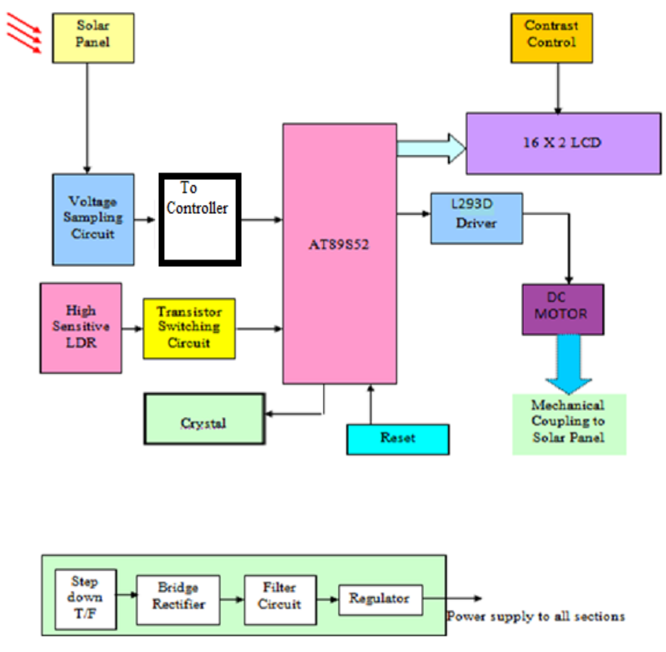


**Fig. 1. Block diagram of the system**

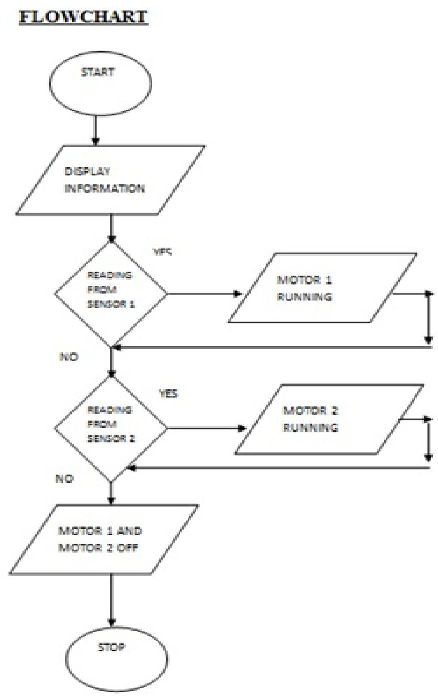


**Fig. 2: Flowchart of the system**

### Prototype of the design

**Fig. 3: Prototype of the system**

The prototype of the design is shown .In this two DC motors are used for covering horizontal and vertical axis which are connected to their respective shafts. Both DC motors works on the 9V DC supply which is provided by the 9V DC adopter. Both are simple DC motors. For reducing the speed of DC motor we insert some delay function. In addition to this we are also using 16*2 LCD (liquid crystal display). This LCD is used for displaying any kind of message. Total 32 characters can be easily seen at the LCD. The shafts should be connected such that the effect of one comes onto the other and the panel can be placed on one of them. We are also using mirror like solar panel having output voltage of 3.5V DC. Depending upon the movement of sun, LDR sense the sunlight and solar panel moves. In this model we are using low cost solar panel having low cost. Additionally we are also using two LDR (light dependent resistor) having high resistance in daylight. The wooden part gives the support for providing the mechanical integration with electronic assembly.

A LED is connected to the solar panel which glows when light falls on it which indicates the charging part. A battery can cover this purpose also. The electronic part consist of ATMEL microcontroller along with LM 358, one each NPN and PNP transistor and the regulated power supply circuit.

AVR is an 8 and 32 bit microcontroller belonging to the family of Reduced Instruction Set Computer (RISC). In RISC architecture the instruction set of the computer are not only fewer in number but also simpler and faster in operation. The other type of categorization is CISC (Complex Instruction Set Computers).

With ease-of-use, low power consumption, and a high level of integration in mind, Atmel® AVR® 8 and 32 bit microcontrollers complement the Atmel | SMART line of ARM®-based microcontrollers and microprocessors to deliver a unique combination of performance, power efficiency and design flexibility. Optimized to speed time-to-market, they are based on the industry's most code-efficient architecture for C and assembly programming. No other microcontroller delivers more computing performance with better power efficiency. Industry-leading development tools and design support, the large AVR family lets us reuse our knowledge when improving our products and expanding to new markets—easily and cost-effectively. ATMEL microcontroller is the brain of the whole system. It controls the functioning of the entire system. AVR microcontrollers are available in three categories:

1. TinyAVR – Less memory, small size, suitable only for simpler applications

2. MegaAVR – These are the most popular ones having good amount of memory (upto 256 KB), higher number of inbuilt peripherals and suitable for moderate to complex applications.

3. XmegaAVR – Used commercially for complex applications, which require large program memory and high speed. For writing the whole program we are using AVR studio which is IDE (integrated development environment). AVR studio is responsible for writing, debugging as well as HEX file generation. In addition to this we are also using AVR dude for writing our HEX code into the target IC. AVR Downloader up loader is a program for downloading and uploading the on chip memories of Atmel's AVR microcontrollers. It can program the Flash and EEPROM, and where supported by the serial programming protocol, it can program fuse and lock bits. AVRDUDE also supplies a direct instruction mode allowing one to issue any programming instruction to the AVR chip regardless of whether AVRDUDE implements that specific feature of a particular chip.

AVRDUDE can be used effectively via the command line to read or write all chip memory types (EEPROM, flash, fuse bits, lock bits, signature bytes) or via an interactive (terminal) mode. Using AVRDUDE from the command line works well for programming the entire memory of the chip from the contents of a file, while interactive mode is useful for exploring memory contents, modifying individual bytes of EEPROM, programming fuse/lock bits, etc.

## 5. MATHEMATICAL MODEL

The Sun path is shown in the figure during different time intervals. From this the rotational angle can be calculated using the equation:

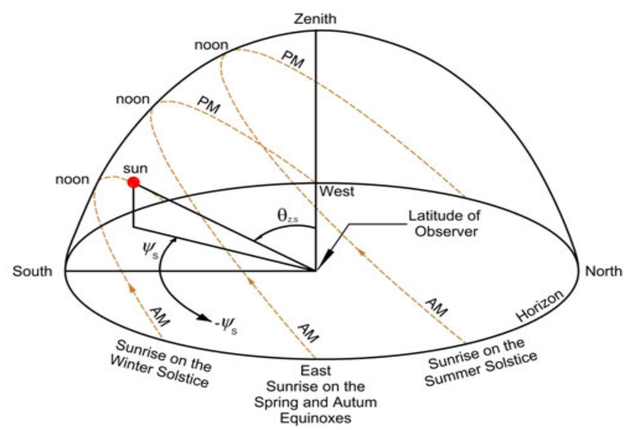


**Fig. 4: Mathematical model of the system**

Path of Sun in winter and summer

*Sin*□□□□□*Sin*□.*Sin*□□*Cos*□.*Cos*□.*Cos*□□) (1)

Where □$z^o$ is the altitude angle of the system.

□$z$ □$90^o$-Zenith angle of the sun,,□□is the latitude ( □□$30^o$ for our example)□ is the hour angle(15 $^o$/hour), where □ =0 at local noon.□ is the solar declination. The□□is calculated from Cooper's equation.

□□ 23.45.*Sin*[360/ 365(284 □*N*)] ) (2)

Here, $N$ is the day of the year (1 to 365), N=1 on the $1^{st}$ of January The rotational angle of the system in the horizontal plane ($\theta_A$) is calculated from the equation here

*Sin□□Cos□.Sin□/ Cos□□□□*$_A$ is the azimuth angle of the system.

**Kinematics**

Earth receives energy of 1000w/m2 which means we can generate 1000 watts of energy from 1m2 area. If we assume a 10% total efficiency of the photovoltaic panels, the predicted output power from the panel will be 100 Watt. Although, it is known that there are panels with higher efficiency but it is preferable to calculate for the least case. Earth complete its one rotation around its axis in 24 hours which means that it rotate by 360 degrees in 24 hour or one day. Therefore one hour cover 3600/24=150, which means one hour angle =150. The system can be designed to move discretely to cover the total daily track in desired steps to reduce the operating time. After sunset, the panel can be designed to return back pointing towards the east to collect the sun radiation next morning. This return process can be done in desired time interval. While the maximum needed power is required by the motors forms 1% of the output of the panel. So it is feasible to rotate the panel using electric motors fed by the output of the panel itself.

Two Light Dependent Resistor's are used as a sensor. They sense the higher density area of sun light. The solar panel moves to the high light density area through Dc motors.

Each LDR is connected to power supply forming a potential divider. Thus any change in light density is proportional to the change in voltage across the LDR's.

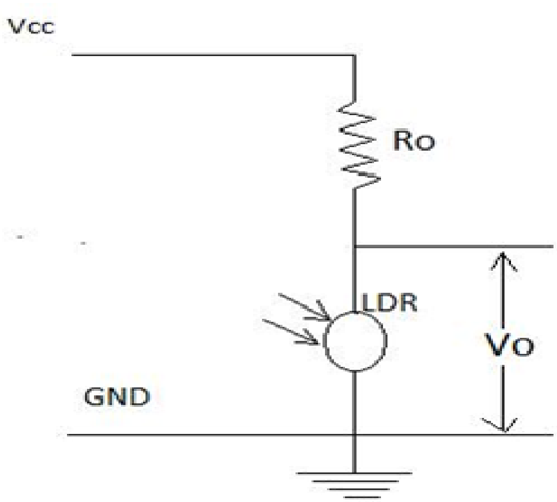


**Fig. 5: Working of LDR**

LDR is a passive transducer hence we will use potential divider circuit to obtain corresponding voltage value from the resistance of LDR. LDRs resistance is inversely proportional to the intensity of light falling on it i.e. Higher the intensity or brightness of light the Lower the resistance and vice versa.

## 6. RESULTS

Sunlight has two components i.e. direct and diffused. Direct component consists of 90% while the diffused consist of 10%.As the maximum of the sunlight is from the direct beam, hence it is important that the panel should be placed such that it can extract maximum of the direct beam, any misalignment of the angle of incidence result in the losses which depends on the cosine of the incidence angle on the panel and is given by the equation.

$$\text{Losses} = 1 - \text{Cos}(i) \quad (3)$$

Where 'I' is the angle of incidence

The table describes the power lost according to different angle of incidence and the value in the percentage with the time duration.

**Table I: Power lost due to misalignment of the panel**

| I | Lost=1-Cos(i) | i | hours | Lost |
|---|---|---|---|---|
| in degrees | in percentage | in degrees | in minutes | in percentage |
| 0 | 0 | 15 | 60 | 3.4 |
| 1 | 0.015 | 30 | 120 | 13.4 |
| 3 | 0.14 | 45 | 180 | 30 |
| 8 | 1 | 60 | 240 | >50 |
| 23.4 | 8.3 | 75 | 300 | >75 |

## 7. CONCLUSION

The article describes the design of the solar tracker by using the algorithm and the use of the debugging, build software AVR studio and AVR Dude for burning the code .In this the main focus in given on the single axis solar tracking along with the prototype in which future scope for building a dual axis tracker is there. With the use of sophisticated assembly both the axes can be covered and the solar energy can be extracted more efficiently. The design described is simple for building a prototype and is efficient.

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