REALIZATION OF MULTI AXIS SOLAR TRACKING SYSTEM USING A MICRO-CONTROLLER

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Abstract- **A Dual Axis Solar Tracker has been designed for the purpose of tapping maximum amount of Solar Energy with minimal losses. This project implements both Horizontal and Vertical rotations, thus the name Dual Axis. Since there is a three dimensional rotation performed, the solar cells are made to move in the desired coordinates periodically and is made to position in line with the sun. By doing so, the proper angular alignment between the sun and the panel is obtained, thereby optimizing the results. This movement of the solar panel is achieved with the help of appropriate Light dependent resistors (LDRs) and stepper motors. The former component is driven by a Micro-controller that has a manually written programmable code in its memory buffer. The coding is done using Micro-controller software. This model is mainly designed with a view of minimum maintenance and maximum efficiency.**

Keywords- **Dual Axis Solar Tracker, Light Dependent Resistors (LDRs), Stepper motors, Microcontroller, Microcontroller Software.**

I.INTRODUCTION

This is the era of depleting natural resources. The need of the hour is thus the invention and implementation of alternative resources for the economic development. Since the start of the first decade of the 21st century, the world has had a lot of modifications in various sectors, including energy management. The community has started working ceaselessly in full swing in order to conserve energy in every possible way. Nowadays, researchers have turned to using natural resources like the wind, water and sun to overcome the growing energy crisis.

Relating to the above, this project has been done based on producing energy taking sun as the primary source. But this model is unlike the conventional Solar Energy system. Since the Earth continuously rotates and revolves, the amount of light intensity varies at every instant. Consequently, it becomes undesirable to have the solar panel stationary, as there are possibilities for the light falling on the panel to reach a minimum value [1], [2]. Thus in order to maximize the efficiency, modifications are made to function as a mobile tracker [3].

II.PHOTOVOLTAIC THEORY

The discovery of this phenomenon dates back to around 1830s. It was found by a French physicist Edmund Becquerel. Harnessing of electrical energy is primarily due to photovoltaic process. Briefly, it states that when a material (such as Germanium, Silicon etc.) is irradiated by a beam of photons (say sunlight), there is an excitation of the molecules present in the material, thus giving rise to production of electrical energy [4]. The energy is created due to movement of electrons in the material.

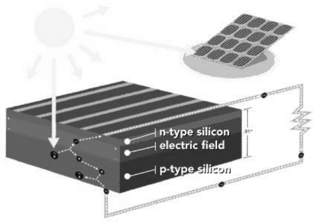

Fig. 1: The photovoltaic effect

Silicon PVs are widely used nowadays due to its cost effectiveness and availability. Chips of Silicon are framed together and made as panels for practical purpose.

III. THEORY OF LIGHT SENSORS

The light sensors are one of the most significant parts of a tracker system. The sensors must be perfectly working in order to obtain accurate positioning of the tracker. The light sensors that can be used generally are photodiodes, photoresistors etc.

LDRs (Light dependent resistors) are the most widely used sensor component. The working principle is similar to that of the Photovoltaic theory. The LDR is made of a semiconductor material with high resistance by default. A typical semiconductor lattice has electrons in its outer kernel. The LDR exhibits a property that whenever there is darkness, resistance becomes infinitely high. This shows that the light intensity is inversely proportional to the resistance offered by the material.

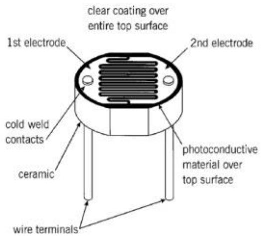

Fig. 2 Light dependent resistor

This principle can be used to track the region in space where the light intensity is maximum (i.e. It is the position which corresponds to perpendicular position between the sun and the PV panel) and positions the panel accordingly. This is overall a cost effective means.

IV.DEVELOPMENT AND DESIGN

The main components of a typical solar tracker are mentioned as follows:

- Solar panel.
- Microcontroller.
- Light sensor.
- Voltage supply.
- Motor.
- Motor driver IC.

Solar panels are available at various sizes and shapes in the market. Depending upon the needs, one can decide which type can be used for the model. The parabolic and flat shapes are widely used. Panels are classified even depending upon the power requirement and the type of crystal used in the panel.

In micro-controllers, components are soldered into a circuit board according to the needs of the individuals. There are various types available depending upon the type of needs.

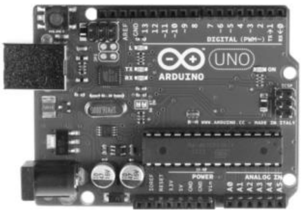

Fig. 3 Micro-controller

For example, the above shown microcontroller has 6 analog inputs, 14 digital I/O-O/P pins (6 can be used as PWM outputs), a 16 MHz ceramic resonator, a USB connection, an ICSP header, a power jack and a reset button. The coding is written in a language which the microcontroller understands and decodes. The serial port link is available and thus with proper interfacing, the output can be viewed in the computer.

Voltage supply is needed for the motors as well as the microcontroller. An SMPS (found in CPUs generally) can be used for this purpose. The voltage supplied must neither be excess or insufficient, as in either of the cases, the system may fail.

The next main component of the system is the motor. 2 motors are used here to rotate the shafts, thereby giving rise to the horizontal and vertical rotations. The motor must be carefully designed in order to have very less inertia. This is to ensure perfect alignments.

Here the motors used are stepper motors. A typical Stepper motor has 200 steps/revolution and a step angle of 1.8°, thus having a total of 360° (200x1.8°).


Fig. 4 Stepper motor

Few of the noteworthy advantages are:

- Maximum dynamic torque.
- Low inertia.
- Accurate step-wise rotation.
- Rotation is in sync with I/P pulse.
- Discrete angular movement.
- High weight bearing capability.

There are various ICs available to drive motors, the differences being their power capability, current limit and ability to drive specific number of motors. The IC that is being used here is L293D which is exclusive to operation of Stepper motors.

L293D is a dual H-Bridge motor driver IC. The packaging type is Dual In-line (DIP) generally. Operating voltage ranges between 5 to 36v. This has built in flyback diodes to minimize inductive voltage spikes. [5]

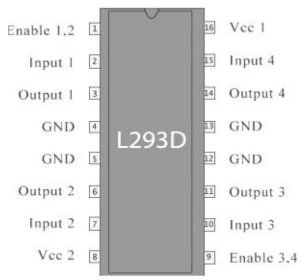

Fig. 5 L293D Motor driver IC

This IC has added advantages over other ICs. Some are as follows:

- Enables both forward and reverse motor rotations.
- Inbuilt heat sinks.
- Good current ratings of 600mA.
- Cheaper price.
- Separate ENABLE pins.

V.CIRCUIT DIAGRAM

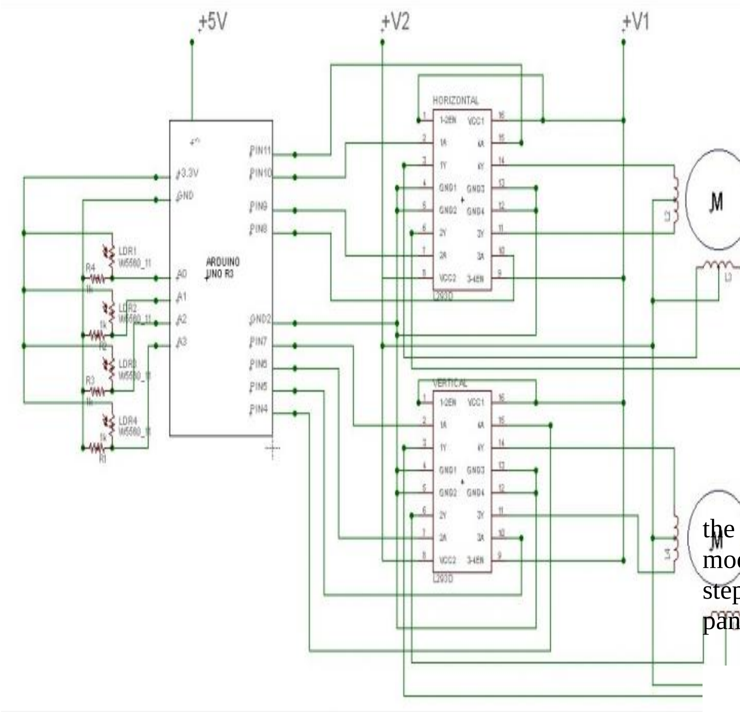

Fig. 6 Circuit diagram of the tracker

LDRs and resistors are paired up and used as potential dividers to measure the light intensity. Power supply is given from the built-in power source from the Arduino. A Common ground is provided. The each voltage reference is given as inputs through pins A0, A1, A2, and A3.

From L293D, pins 4, 5, 12, 13 are connected to the ground. Pins 1, 9 are Enable pins connected to V_{cc} from the SMPS. Control pulses 1, 2, 3, 4 are drawn from the micro-controller output for each motor and given to input terminals of IC pins 2, 7, 10, 15. Motor positive voltage is given through pin 8 with separate supply from SMPS.

Motor has 5 terminals, 4-connected to amplified control pulses from the L293D pins 3, 6, 11, 14.

VI.WORKING

The basic block diagram of the Tracking system can be visually represented with a block diagram as in Fig. 7. The main components are enlisted in the above blocks. Firstly this starts with the voltage regulator or the voltage source, which is the power hub of the system.

A supply voltage of 5v is fed to the microcontroller. 4 LDRs are used here, each corresponding to the geographical directions North, South, East and West. The 4 LDRs are set up in 2 pairs to determine the azimuthal and zenith angles proportionate to the light intensity differences. This is coded in the Arduino Interface. The flowchart of the coding is explained in Fig. 8.

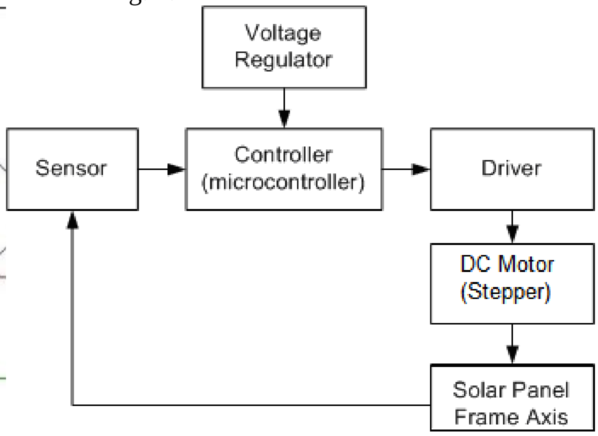

Fig. 7 Basic block diagram

The microcontroller generates pulses in accordance to the sensed readings and is sent to the driver IC where they are modulated and fed to the motor. The motor is then rotated in steps to accurately get positioned. This in turn rotates the solar panel.

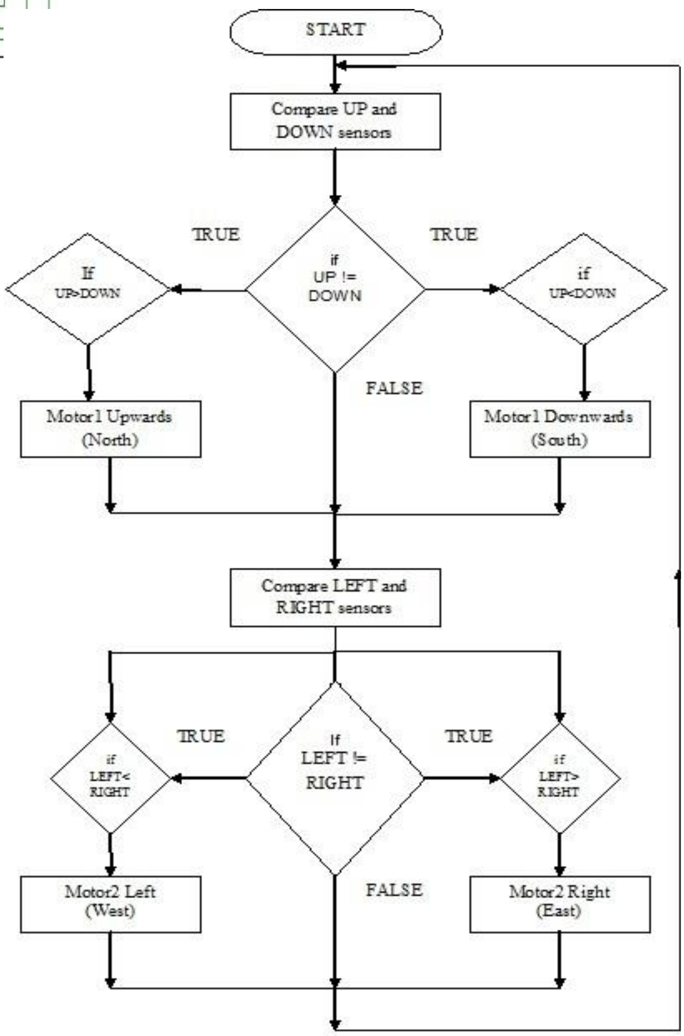

Fig. 8 Flow of control between LDRs

VII.UNIQUE FEATURE

In various multiple axis trackers, the movement of the horizontal axis affects the vertical axis coordinates, as both are mutually geared. Whereas in this model, it is ensured that the both the motors that are responsible for the horizontal and vertical movements are placed in a common stationary base table. This is illustrated in Fig. 10.

This makes them independent of each other and thus, it aids to give improved results. The most prime advantage of such a setup is that the load associated with the main horizontal motor is considerably reduced. So the motor doesn't get heated up soon. And also, gearing is done in order to lessen the frictions between axles.

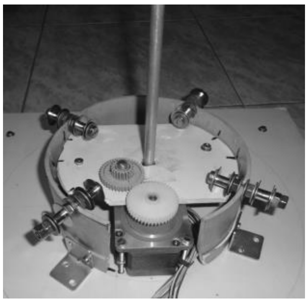

Fig. 9 Base with 2 independent stepper motors

VIII.GRAPHICAL ANALYSIS

On real time basis the analysis was made between the stationary and mobile solar panels. The results were obtained and tabulated and the graphical analysis is made between them.

TABLE I
VOLTAGE READING

S. No.	Time	Stationary Panel (v)	Mobile Panel (v)
1.	8:00a.m	6.49	6.68
2.	9:00a.m	6.70	6.83
3.	10:00a.m	6.89	6.95
4.	11:00a.m	6.95	7.08
5.	12:00p.m	7.12	7.13
6.	13:00p.m	7.05	7.09
7.	14:00p.m	7.01	7.08
8.	15:00p.m	6.85	7.01
9.	16:00p.m	6.68	6.88
10.	17:00p.m	6.45	6.68

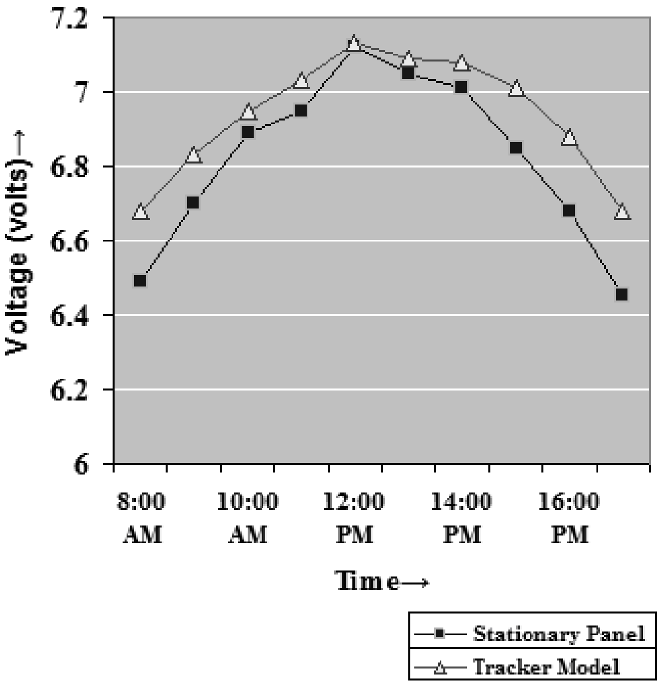

Fig. 10 Voltage vs. Time characteristics-comparison of two real time models

IX.FINAL MODEL

The final model is thus designed and developed and ready to be used as a working model.

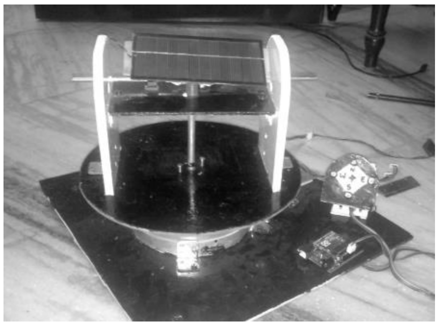

Fig. 11 Final system model

TABLE III
PROJECT DETAILS

ASPECTS	SPECIFICATIONS
Dimensions	38cm x 38cm x 28cm.
Weight	2.83 kg.
Materials Used	Base – Foam board. Support – PVC. Axles – Aluminium Pipe.
Panel Ratings	1W, 6v.

X.CONCLUSION

An insight into the modelling and working of a minimal powered Dual Axis Solar Tracker was seen and designed successfully. As the era of technology is ceaselessly changing, there is a need to update and upgrade things in every possible way. As the energy crisis keeps augmenting day by day, it is wise to implement innovative techniques that are cheap, self sufficient, economically feasible and commercially viable. The projects of this kind can be realized and commercially implemented to cope up the crisis.

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