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Real-time Arduino Controller Inexpensive Active Dual Axis Solar Tracker

[1] Singireddy Mallikarjun, [2] Dr. S.Chandra Shekar Reddy
Research scholar, Mewar University, Rajastan
Professor, CJITS, Jangoan, Warangal, Telangana

***Abstract*: -- Renewable energy is generally defined as energy that is collected from resources and continuously replenished, such as sunlight, water, wind, tides and biomass. Most of the renewable energy source comes either directly or indirectly from the sun. This solar energy can be utilised by using solar photovoltaic cells and photovoltaic effect to convert solar energy into electrical energy [1]. There are different types of mechanisms to improve the solar cell efficiency and to reduce the cost. The solar tracking system is the most appropriate method to improve the efficiency of solar cells by tracking the sun with respect to its change in direction. Thus the solar trackers come into existence. The main aim of this paper is the design and construction of a real-time dual axis Arduino controlled solar tracker to get the maximum power from the solar panels by changing their direction with respect to the sun. This setup uses Light Dependent Resistors (LDR) to sense the position of the sun which is interfaced to an Arduino Uno microcontroller which then commands a pair of linear-actuators to re-orient the solar panel in order to stay perpendicular to the sun rays. The design was constructed successfully and tested to determine the raise/gain in efficiency. The result shows the new system performs XX.XX% better than the immobile solar tracking system.**

***Keywords*- Light dependent resistor, Solar PV panels, Dual axis Arduino controller solar tracker, linear actuators**

I. INTRODUCTION

Renewable energy is generally defined as energy that is collected from resources and continuously replenished, such as sunlight, water, wind, tides and biomass. Most of the renewable energy source comes either directly or indirectly from the sun. This solar energy can be utilised by using solar photovoltaic cells and photovoltaic effect to convert solar energy into electrical energy[1]. There are different types of mechanisms to improve the solar cell efficiency and to reduce the cost. Solar tracking system is the most appropriate method to improve efficiency of solar cells by tracking the sun with respect to its change in direction. Thus the solar trackers come into existence. If solar trackers are not used; solar panels should be oriented in an ideal position i.e, at a tilt angle equal to latitude of the sit facing south for northern hemisphere [2]. Several tracking system designs are available which have single axis or Dual axis of freedom. This includes both active and passive systems. Single axis trackers can be classified as: horizontal single axis tracker (HSAT); vertical single axis tracker (VSAT); tilted single axis tracker (TSAT) and polar aligned single axis tracker (PASAT) [3]. Horizontal axis tracker is used in tropical regions where day time is short and sun gets very high at moon time. Vertical axis tracker is used at places where summer days are long and sun does not get very high. Using single axis of tracking cannot provide a significant power gain to the system [3;4]. Dual axis solar trackers have both a horizontal and a vertical axle and so can track the sun's change in motion exactly anywhere in the world. This type of system is used to control astronomical telescopes, and so there are a number of software available to automatically detect and track the motion of the sun across the sky. Dual-axis trackers track the sun from both north to south and east to west for added power output (approx 40% gain) and convenience[4]. In active tracking system; the sun's position during the day is continuously determined by feedback sensors [8]. The sensors will trigger of actuator; which will in turn cause the movement of the solar panels will always be perpendicular to the sun throughout the day. The drawback of such a system is that it is very sensitive to certain atmospheric conditions and might not be able to continue tracking the sun on a cloudy day. One of the most important factor behind the selection of a tracking system is cost. To reduce the cost of the system; Arduino Uno; single-board microcontroller; instead of servo motor or stepper motor a pair of linear actuators has been used. A linear actuator is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators are used in machine tools and industrial machinery. Hydraulic or pneumatic cylinders inherently produce linear motion. Many other mechanisms are used to generate linear motion from a rotating motor. It consumes power when it actuates to the commanded position; but after that it rests; whereas stepper motors continue to consume power to lock in and hold the commanded position. The actuators uses less energy for the same functionality. Active trackers measure the light intensity from the sun by using LDR's to determine where the solar modules should be pointing. Light dependent resistors are positioned on the tracker at various locations in specially shaped holders. If the sun is not facing the tracker

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directly there will be a difference in light intensity on one LDR compared to another and this causes to determine in which direction the tracker has to tilt with the help of the linear actuators in order to be facing the sun.

II. METHODOLOGY

A solar tracker is a perfect tool for track the path of the sun from east and west during daytime [20]. Usually solar tracker is classify into two group i.e. i) Single axis tracker and ii) Dual axis tracker. For a conscientious line of longitude, every day sun moves from east to west on a fixed solar path [20]. However, the sun moves through 460 degrees north and south throughout the seasonal revision as shown in figure1.

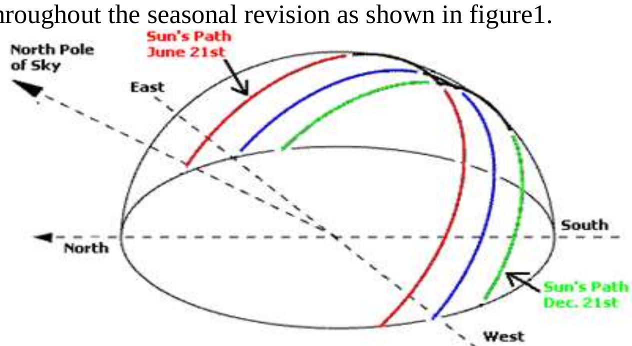

Figure 1: Path of sun during different seasons

In our proposed model we have partiality to use micro controller based dual axis solar tracking system [16]. The angles of occurrence of sun beam are going to be 0°. We use light dependent resistors (LDR) for trace intensity of the light of the sun [20]. LDR incessantly monitor the solar emission and this data is transferred to the pair of linear actuators via arduino-controller [20]. Where the intensity of sunshine is highest the actuators moves the panel to that direction [20]. Our proposed model is to calm the ability expenditure and make the highest use of solar power generation [20]. The main plus point of our proposed model is that we use two linear actuators. In order to control two motor, system desires a lot of power.

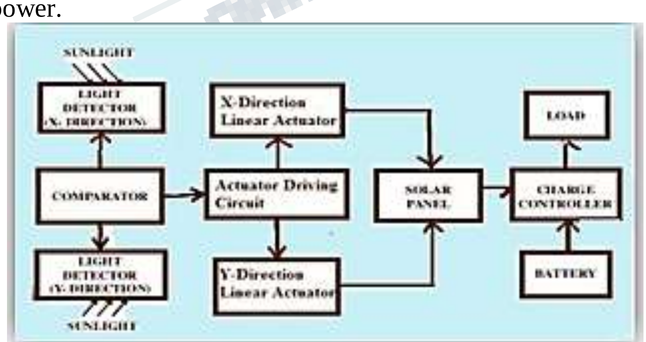

Figure 2: Block diagram representation

Within Single Axis Solar Tracker: 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.

A. Hardware Implementation

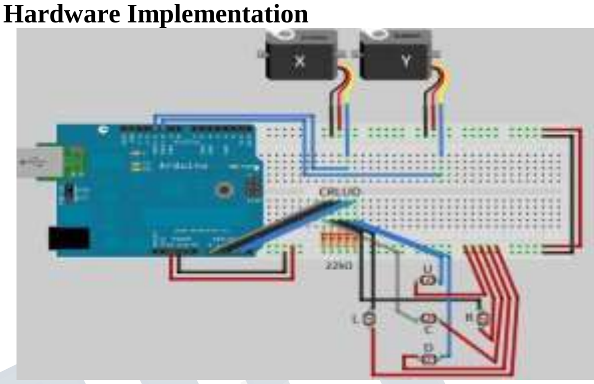

Figure 3: Shows the Hardware layout and their Interconnections

B. Software implementation

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, MaxMSP).The boards can be built by hand or purchased preassembled; the software can be downloaded for free. The hardware reference designs (CAD files) are available under an open-source license; you are free to adapt them to your needs. The arduino program installation on board is shown in figure 4.

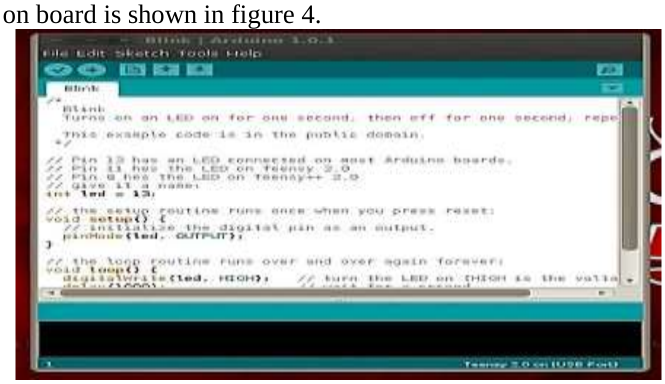

Figure 4: Software (program) installation to arduino microcontroller

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C. Working

LDR's are used as the main light sensors. Two linear actuators 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. LDRs sense the amount of sunlight falling on them. Four LDRs are divided into top, bottom, left and right. 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 actuator will move in that direction. If the bottom set receives more light the horizontal actuator moves in that direction For angular deflection of the solar panel as shown in figure 6.

Figure 5: Representation and working phenomenon of LDR's

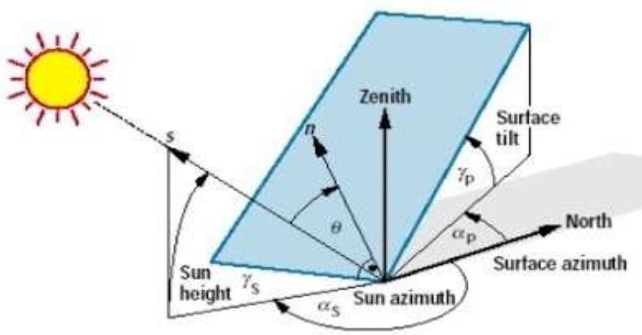

Figure 6: Direction of panel based on Azimuth angles

The analog values from two left LDR's and two right LDR's are compared. If the left set of LDR's receive more light than the right set, the horizontal actuator will move in that direction. If the right set of LDR's receive more light, the vertical actuator moves in that direction. The above software and hardware implementations are collectively combined and develop the complete dual axis solar tracker. Figure 7 shows the complete developed dual axis solar tracker.

Figure 7: Dual-axis solar tracker stand with pair of linear actuators

.D. Flow chart & Algorithm

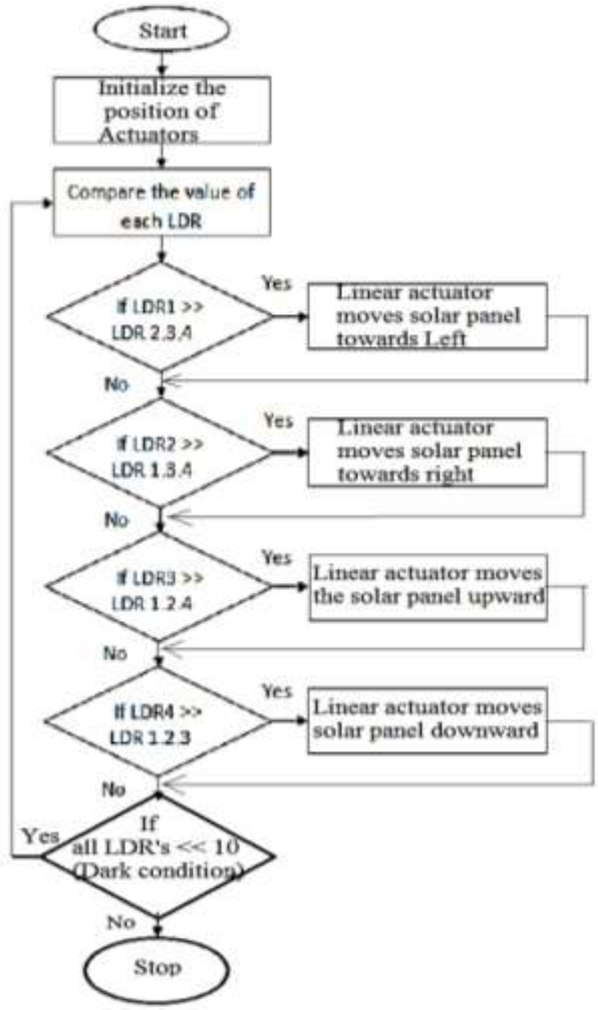

Figure 8 shows the flow chart describing algoritm of dual axis solar tracker

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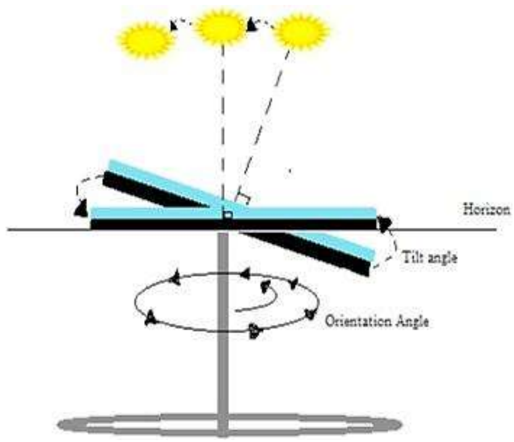


E. Linear Actuators

A linear actuator is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators are used in machine tools and industrial machinery, in computer peripherals such as disk drives and printers, in valves and dampers, and in many other places where linear motion is required. Hydraulic or pneumatic cylinders inherently produce linear motion. Many other mechanisms are used to generate linear motion from a rotating motor. Figure 9 shows the linear actuator used in this section.

Specifications:

Input Voltage	12V DC
Stroke	1-40 inches
Force	35 lbs, 50 lbs and 150 lbs
Speed	0.59"/sec (150 lbs); 1.18"/sec (50 lbs); 2.00"/sec (35 lbs)
Protection Class	IP54
Operational Temperature	-25C~+65C
Noise	db<45(A)
Duty Cycle	25%
Limit Switch	Built In, Non-Adjustable
Current (full load)	5A
Mounting Holes	0.25"
Motor Type	Brushed DC Motor
Screw Type	ACME
Housing Type	6062 Aluminum Alloy
Wire Length	40"
Fully Retracted	4.13" + stroke
Fully Extended	4.13" + stroke + stroke

List of main components used in development of solar tracker and implementation are mentioned in below table.

S.no	Name of the Component	Range	Quantity
1	Microcontroller	Arduino Uno 328P	1
2	Solar panel	24V	1
3	Light dependent resistor	LDR 5mm	5
4	Linear Actuators	12V,dc	2

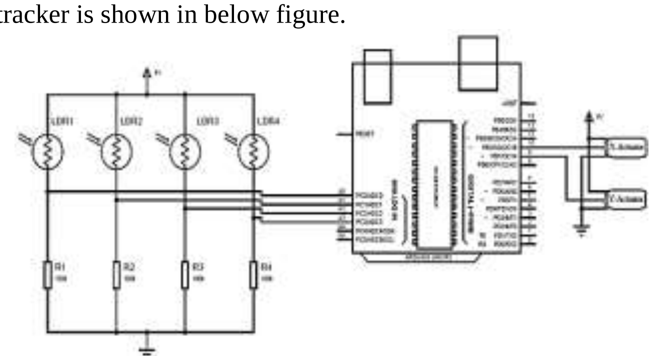
Table 1: List of components

III. REAL-TIME MONITORING AND EVALUATION

In this project the arduino Uno acts as an interface between the solar panel and the arduino IDE. Hence the Real-time monitoring and static solar panel has been performed. (Pictures of monitoring)

IV. RESULT

The dual, axis solar tracking system was successfully made and output of the same was validated by plotting the measured values. Block diagram representation for dual axis solar tracker is shown in below figure.



(pictures of result)


installed prototype dual axis solar tracker

Observations on a sunny Day

Time	Solar azimuthal angle	Solar Inclination angle
8.00 AM	10°	17 °
10.00 AM	32 °	17.5
12.00 PM	60 °	18
2.00 PM	96°	19 °
4.00 PM	120°	20 °
5.00 PM	126	17

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