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Optimization and Performance Evaluation of Single Axis Arduino Solar Tracker

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Abstract-The use of clean energy (Solar, Wind etc) in other words, renewable energy is becoming more important for lowering global warming as the world becomes hotter as a result of global warming . The aim of this paper is to consume the maximum solar energy through solar panel. A Solar Tracker is a device onto which solar panels are built-in which tracks the motion of the sun ensuring that maximum amount of sunlight strikes the panels all over the day. Power output from a solar cell will be high when it is facing the sun. The components used for its construction are servo motor, Arduino Mega (microcontroller) and LDR. Light Dependent Resistors (LDRs) are used for sunlight detection. The active sensors continuously monitor the sunlight and alternate the panel towards the direction of the sun. Four light dependent resistors (LDR) have been used to trace the synchronization of sunlight by detecting brightness level of sunlight. For rotation, two standard servo motors are been used. The effectiveness of output power will increase when compared with the traditional model(Fixed solar panel).

Keywords- *Solar tracker, PV cell, Efficiency, Arduino, Servo motor.*

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I. INTRODUCTION

Life on the earth planet is the manifestation of energy. The origin of fire, heat and light is energy. Thermal plants (coal, oil, gas) ,nuclear and hydro power stations are the major conventional methods of generating electrical energy. Rise in the cost of fossil fuels has created an urgency to conserve these fuels, and engineers across the world are looking for alternative renewable sources of energy. Renewable energy sources occur in nature which are regenerative (or) exhaustible like solar energy , wind energy , hydro power , geo thermal , biomass ,tidal and wave energy. Most of these alternative sources are the manifestation of solar energy. Solar PV panels directly convert radiation from the sun into electrical energy. Their efficiency is 24.5% on the higher side. Three possible ways of increasing the efficiency of the solar PV panels are through increase of cell efficiency, maximizing the power output and the use of a tracking system. For places around the equator where there is no significant change in the apparent position of the sun, single axis trackers are best option. The efficiency of the tracking system and weather are the key roles to indicate how much level the efficiency is to be improved.

II. TYPES OF SOLAR TRACKERS

A solar tracker is a device which rotates towards the sun's direction hence ensuring that it is always exposed to the sun no matter the time of day or location of the panel. The single axis trackers follows the sun's trajectory from east to west throughout the day. They have one degree of freedom which act as the axis of rotation. A single linear actuator (motor) is used to drive the panel according to the sun movements. Various types of single axis trackers are horizontal single axis trackers (HSAT), horizontal single axis tracker with tilted modules (HTSAT), vertical single axis trackers (VSAT), tilted single axis trackers (TSAT) and polar aligned single axis trackers (PSAT).

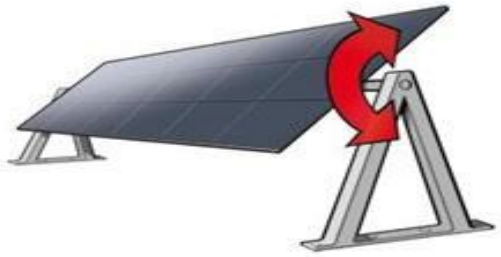

Fig 1. Single axis tracker

Dual Axis trackers have two degrees of freedom added to the system. For maximum absorption of sunlight, the panel can move both in east-west and north-south direction. Since two linear actuators are used , they are more efficient than the single axis solar trackers.

Fig 2. Dual axis tracker

III. SOLAR RADIATION CONCEPT

For utilization of solar energy , a study is carried out of radiations received on earth's surface. Solar radiations pass through the earth's atmosphere and are subjected to scattering and atmospheric absorption. Apart of scattered radiations is reflected back into space. Sunlight has two components, the direct beam and diffuse beam. Solar radiation received on the earth's surface without change in direction, is called beam (or) direct radiation. Diffuse radiation is that solar radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere. The total solar radiation received at any point on the earth's surface is the sun of the direct and diffuse radiation. In general sense, it is referred as the insolation at the point. Most of the sun energy is in the direct beam, so maximum collection requires the sun to be visible to the panels as long as possible.

IV. WORKING OF SOLAR PHOTO VOLATAIC

A solar PV cell converts the energy of light directly into electricity by the photovoltaic effect. PV / Solar cells are framed in series and in parallel to form a PV / Solar Panel (Module). The number of series cells indicates the voltage of the Panel (Module), whereas the number of parallel cells indicates the current. PV Array is a combination PV modules in series and parallel.

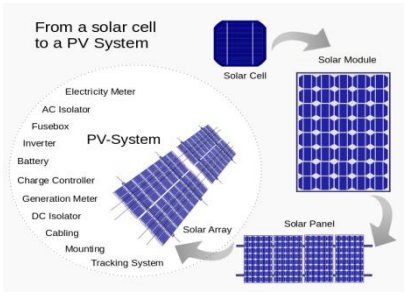

Fig 3.Photovoltaic panel or array

V. HARDWARE MODEL OF SOLAR TRACKER

The circuit of the solar tracker system is segregated into three stages. Input stage consists of sensors second a program in embedded software in the microcontroller and third stage consists of servo driving unit. Arduino sketch loaded into the Arduino mega 2560 forms the embedded software. A card board houses all the components. The three stages are designed independently and combined into one system. It also ensures that if any errors are there, we dismantle that part and corrected.

VI. BLOCK DIAGRAM OF SOLAR TRACKER

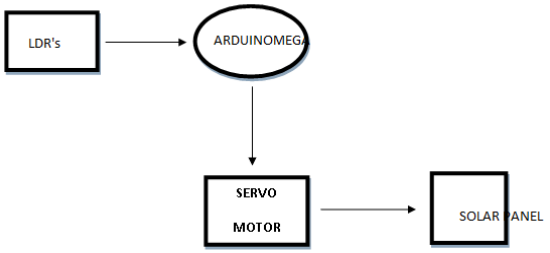

Fig 4. Block diagram of solar tracker

VII. CIRCUIT DIAGRAM OF SOLAR TRACKER UNIT

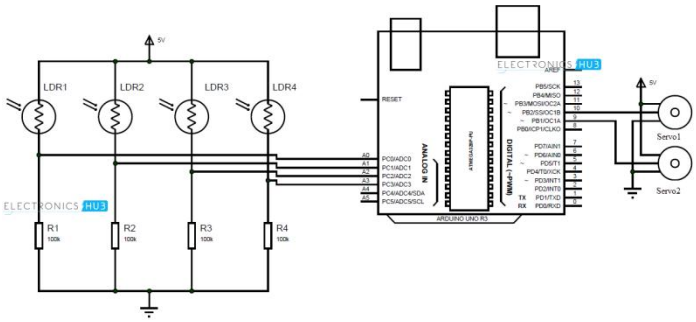

Fig 5. Circuit diagram of solar tracker unit

VIII. SERVOMOTORS AND SERVO MECHANISM

Fig 6. Servo motor

Servo motor is an automatic electrical motor which can push or rotate an object at some specific angles or distance. **Servo Mechanism** consists of three parts :Controlled device, output sensor and feedback system. Even in the presence of disturbances, servomechanism maintains output of a system at desired value.

IX. LDR AND THE CONCEPT OF USING FOUR LDRS

Light Dependent Resistors (LDRs) are used for sunlight detection. The active sensors continuously monitor the sunlight and alternate the panel towards the direction of the sun. Four light dependent resistors (LDR) have been used

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to trace the synchronization of sunlight by detecting brightness level of sunlight.

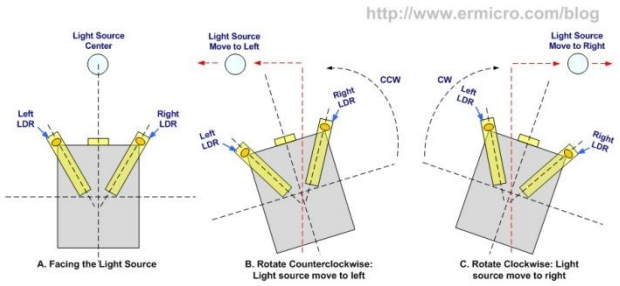

Fig 7. Concept of rotation for LDRs

When two LDRs having the same light intensity , the position is stable. When the light intensity moves , the sun moves from west to east , intensity of light falling on the LDRs changes and it is calibrated into voltage using voltage dividers. The changes in voltage are compared using built-in comparator of microcontroller and motor is used to rotate the solar panel in a way so as to track the light intensity.

X. MICROCONTROLLER (ARDUINO MEGA-2560)

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, 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. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

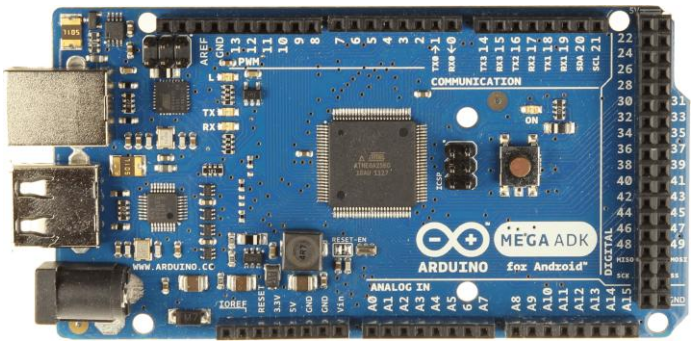

Fig 8. Arduino mega-2560

XI. CONSTRUCTION OF TRACKING STRUCTURE

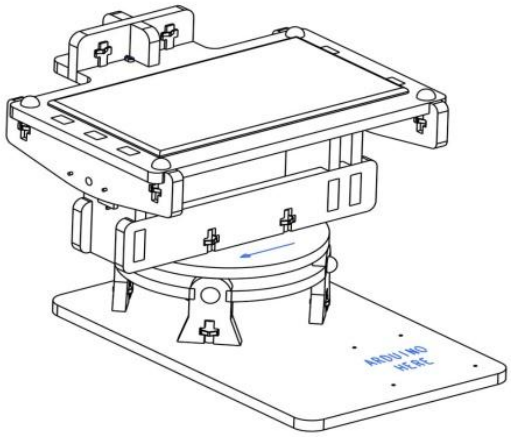

***Fig 9.** Mounting structure*

Step 1: Attach the servo to their mounts

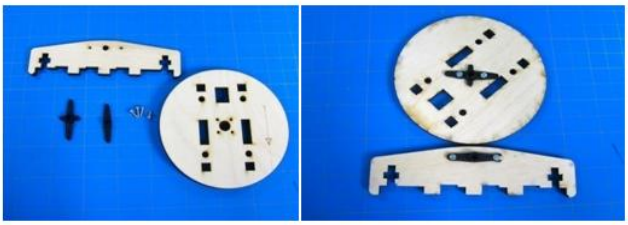

Fig 10. Attaching the servo to their mounts

Step 2: Attach the servo arms to the Mounts

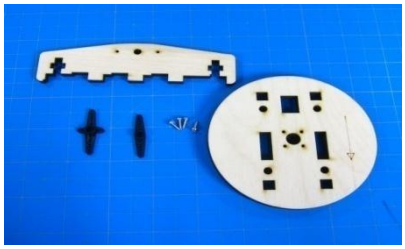

Fig 11. Attaching the servo arms to the mounts

Step 3: Building the Base

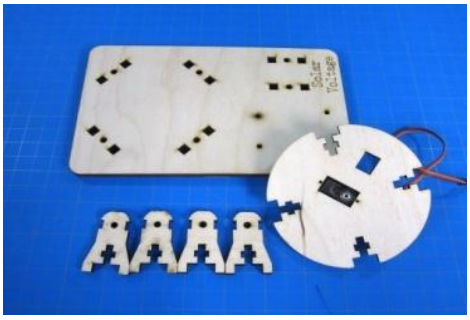

Fig 12. Building the Base

Step 4: Building the Top

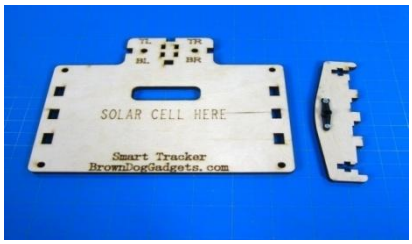

Fig 13. Building the top

Step 5: Build the Center

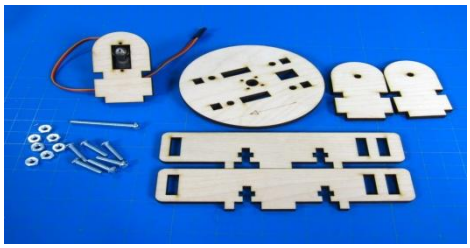

Fig14 . *Build the center*

Step 6: Home the Base Servo

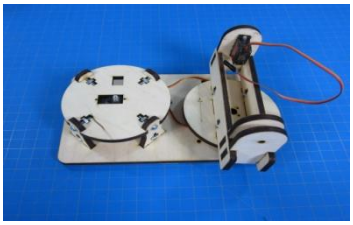

Fig 15.*Home the Base Servo*

Step 7: Home the Center Servo

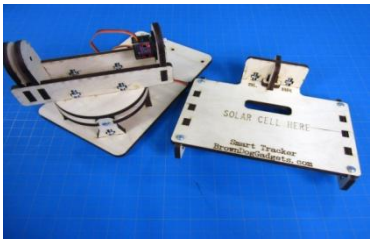

Fig 16 .Home the center Servo

Step 8: Check Everything

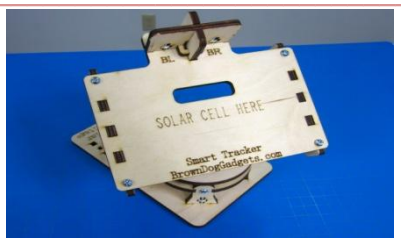

Fig 17. Check Every thing

Step 9: Attach the Arduino and Hook up the sensors

Grab your four Light Sensitive Resistors. The legs are way too long. Remove 2/3rds of their legs. Push all the four LDRs into the top four holes and solder one of the two ends of the each LDR and add an extra wire to that soldering point, so that it can be grounded.

Step 10: Arduino Connections

After completing all the connections the circuit will be as shown in the below figure.18

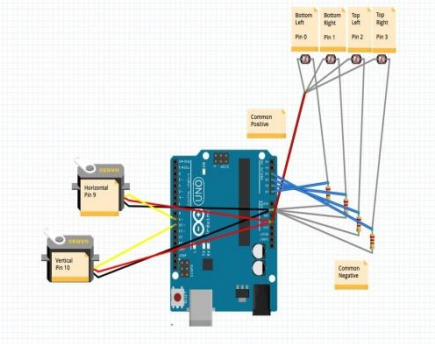

Fig 18 . Arduino connections

XII. WORKING OF THE PROTO TYPE MODEL

Light sensors are nothing but LDRs. Two servo motors are fixed to the structure that holds the solar panel. The program for Arduino is uploaded to the microcontroller. 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 servo will move in that direction. If the bottom LDRs receives more light, the servo moves in that direction.

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 receives more light than the right set, the horizontal servo will move in that direction. If the right set of LDRs receives more light, the servo moves in that direction.

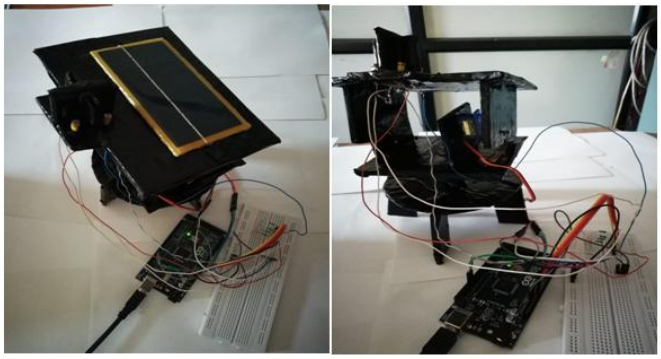

Fig 19 : Solar tracker prototype model

XIII. CONCLUSION

The proto type tracking system successfully sketched the light source even it is a small torch light, in a dark room, or it is the sun light rays. The Arduino solar tracker with servo motor is employed by means of Arduino mega 2560 microcontroller. The essential software is developed via Arduino Mega. Due to economical and reliability of this solar tracker , it suitable for the rural usage. The purpose of renewable energy from this paper offered new and advanced idea to help the people.

The designed Solar tracking system is an efficient means of obtaining optimal solar energy from the sun with the help of microcontroller and servo motor. By constantly aligning the photovoltaic panel with the sun, it directly receives sunlight falling on its surface there by generating more electricity. However, the designed prototype of the solar tracker is a miniature of the main system and so there are a number of limitations. The number of LDRs should be increased for the practical case.

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