IOT BASED SOLAR TRACKING SYSTEM FOR EFFICIENT POWER GENERATION

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Abstract: The main goal of this project is to design a very precise solar tracker and share the information through IoT. In this work sensing of the sun position carried out in two stages primary and secondary. Primary stage or indirect sensing performed via sun-earth relationship as a coarse adjustment and second stage or direct sensing performed via set of LDR sensors as output tuning to trims the azimuth and altitude angles. If the weather is cloudy or dusty, the tracking system uses primary stage or sun-earth geometrical relationships only to identify the location of the sun; so the system tracks the position of the sun regardless the weather condition. The energy extracted from photovoltaic (PV) or any solar collector depends on solar irradiance. For maximum extraction of energy from the sun, the solar collector panel should always be normal to the incident radiation Solar trackers moves the solar collector to follow the sun path and keeps the orientation of the solar collector at an optimal tilt angle. Solar tracking system improves substantially the energy efficiency of photovoltaic (PV) panel. The project is divided into two parts; hardware and software. Hardware part generally composed of solar panel, two-DC motors, LDR sensor module, temperature sensor, humidity sensor and electronic circuit. Software part represents the thinking behaviour of the system, that is how the system acting under several weather conditions. In this paper, an automatic solar tracking system is designed and developed using Light Dependent Resistor (LDR) and DC motors on a mechanical structure with gear arrangement. It is implemented through Arduino UNO controller based on Sun Earth Geometry. The results indicated that the automatic solar tracking system is more reliable and efficient than fixed one.
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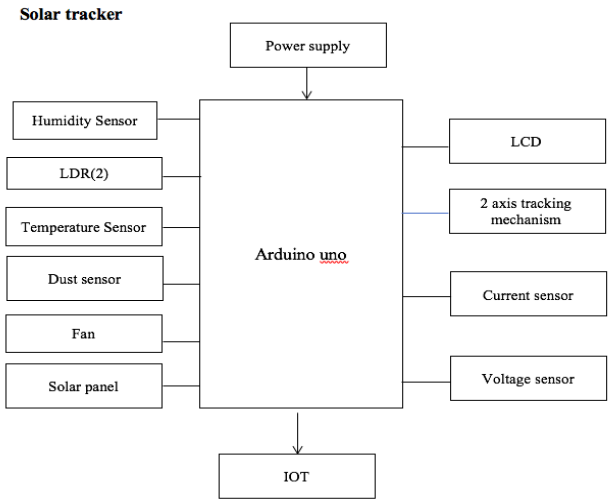
Keywords: Arduino UNO; LDR; Photovoltaic (PV) panel; Solar Tracking System; voltage Sensor; current Sensor; Humidity Sensor; Temperature Sensor; Dust Sensor Internet of Things(IoT).

I. INTRODUCTION

A solar tracker is a device for orienting a solar photovoltaic panel, day lighting reflector or concentrating solar reflector or lens toward the sun. Solar power generation works best when pointed directly at the sun, so a solar tracker can increase the effectiveness of such equipment over any fixed position. The solar panels must be perpendicular to the sun's rays for maximum energy generation. Deviating from this optimum angle will decrease the efficiency of energy generation from the panels. A few degrees of misalignment will only cause 1% to 5% of energy loss, while larger angles of 10° to 20° will significantly decrease the energy generation of up to 35%. Alt hough, this loss is also dependent on the material and pattern of the protective glass that covers the solar panel. An active tracker uses motors to direct the panel toward the sun by relying on a sensing circuit to detect light intensity. There are two main ways to mount a solar panel for tracking; single axis and dual axis. Single axis trackers usually use a polar mount for maximum solar efficiency. Polar trackers have one axis aligned to be roughly parallel to the axis of rotation of the earth around the north and south poles. When compared to a fixed mount, a single axis tracker increases the output by approximately 30% The second way is a two axis mount where one axis is a vertical pivot and the second axis is the horizontal. By using a combination of the two axes, the panel can always be pointed directly at the sun. This method increases the output by approximately 36% compared to stationary panels.

II. PROPOSED SYSTEMS

The maximum efficiency of a solar panel is extracted using two combined techniques. The first one we have to implement is a micro-controller based Solar-tracking system. The system checks the position of the sun and controls the movement of a solar panel so that radiation of the sun comes normally to the surface of the solar panel and the second is to install an MPPT charge controller which makes the Inverter to work at maximum power point. So that under any climatic conditions maximum power is extracted. This way we make efficient use of both solar panel and solar-energy from sun. There are different methods of tracking out the power form the panel as discussed above.



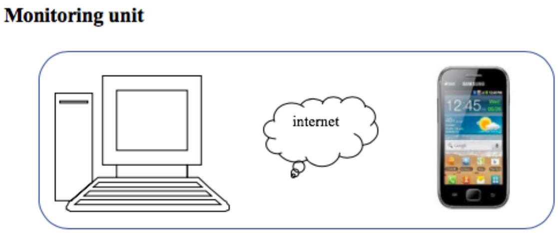


Fig 1: Block Diagram of Proposed System.

As mentioned in above topic we came to know that the project concept aims at extracting maximum power from solar panel by using light sensors (LDR'S).And by the status of LDR's the panel rotates with the help of 3.5V dc Motor in any direction and if the sunlight is more in any direction then it rotates to that direction. The output from panel is derived to an DC-DC Boost Converter which is used to increase the voltage without change in current rating their by increasing the battery charging condition. Where the output is given to Battery which is used to drive loads in failure of supply and in day times from panel after boost converter. The panel is also provided with temperature sensor, humidity sensor, Dust sensor, Voltage sensor and Current sensor. The sensors sense the respective parameters and data is sent to the monitoring unit as well as in shown on LCD screen. When the Temperature is high enough the microcontroller switch on the Fan by using the power derived from the solar Panel. The whole setup is provided by a dust sensor which sensor the dust on the panel. The dust sensor and LDR's helps in increasing the efficiency of the solar panel.

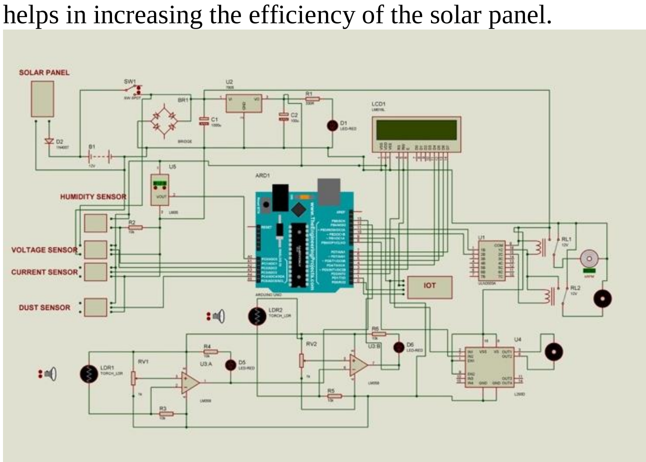


Fig 2: Schematic Diagram.

III. PROBLEM STATEMENT AND OBJECTIVE

Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. At the educational level, it is therefore critical for engineering and technology students to have an understanding and appreciation of the technologies associated with renewable energy. One of the most popular renewable energy sources is solar energy. Many researches were conducted to develop some methods to increase the efficiency of Photo Voltaic systems (solar panels). One such method is to employ a solar panel tracking system. This system deals with a RTC based solar panel tracking system. Solar tracking enables more energy to be generated because the solar panel is always able to maintain a perpendicular profile to the sun's rays. Development of solar panel tracking systems has been ongoing for several years now. As the sun moves across the sky during the day, it is advantageous to have the solar panels track the location of the sun, such that the panels are always perpendicular to the solar energy radiated by the sun. This will tend to maximize the amount of power absorbed by PV systems. It has been estimated that the use of a tracking system, over a fixed system, can increase the power output by 30% -60%. The increase is significant enough to make tracking a viable preposition despite of the enhancement in system cost. It is possible to align the tracking heliostat normal to sun using electronic control by a micro controller. Design requirements are:

1) During the time that the sun is up, the system must follow the sun's position in the sky.

2) This must be done with an active control, timed movements are useful. It should be totally automatic and simple to operate.

The operator interference should be minimal and restricted to only when it is actually required. The major components of this system are as follows.

1) Solar Panel
2) LDR'S
3) DC motors.
4) Temperature sensor
5) Humidity sensor
5) Photovoltaic cells
6) Dust sensor
7) Current sensor
8) Voltage Sensor
9) ESP8266 Wifi Module

IV. LITERATURE SURVEY

A. Technology of Solar Panel

Solar panels are devices that convert light into electricity. They are called solar after the sun or "Sol" because the sun is the most powerful source of the light available for use. They are sometimes called photovoltaic which means "light-electricity". Solar cells or PV cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charge layers. A solar panel is a collection of solar cells. Although each solar cell provides a relatively small amount of power, many solar cells spread over a large area can provide enough power to be useful. To get the most power, solar panels have to be pointed directly at the Sun. The development of solar cell technology begins with 1839 research of French physicist Antoine-Cesar Becquerel. He observed the photovoltaic effect while experimenting with a solid electrode in an electrolyte solution. After that he saw a voltage developed when light fell upon the electrode. According to Encyclopedia Britannica the first genuine for solar panel was built around 1883 by Charles Fritts. He used junctions formed by coating selenium (a semiconductor) with an extremely thin layer of gold. Crystalline silicon and gallium arsenide are typical choices of materials for solar panels.

Gallium arsenide crystals are grown especially for photovoltaic use, but silicon crystals are available in less-expensive standard ingots, which are produced mainly for consumption in the microelectronics industry. Norway's Renewable Energy Corporation (REC) has confirmed that it will build a solar manufacturing plant in Singapore by 2010 -the largest in the world. This plant will be able to produce products that can generate up to 1.5 gigawatts (GW) of energy every year. That is enough to power several million households at any one time. Last year, the world as a whole produced products that could generate just 2 GW in total.it was implemented with a dc motor and a dc motor controller. The solar energy conversion unit consisted of an array of solar panels, a step up chopper, a single phase inverter, an ac mains power source and a microcontroller based control unit.

B. Evolution of Solar Tracker

Since the sun moves across the sky throughout the day, in order to receive the best angle of exposure to sunlight for collection energy. A tracking mechanism is often incorporated into the solar arrays to keep the array pointed towards the sun. A solar tracker is a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. When compare to the price of the PV solar panels, the cost of a solar tracker is relatively low. Most photovoltaic (PV) solar panels are fitted in a fixed location-for example on the sloping roof of a house, or on framework fixed to the ground. Since the sun moves across the sky though the day, this is far from an ideal solution. Solar panels are usually set up to be in full direct sunshine at the middle of the day facing South in the Northern Hemisphere, or North in the Southern Hemisphere. Therefore morning and evening sunlight hits the panels at an acute angle reducing the total amount of electricity which can be generated each day.

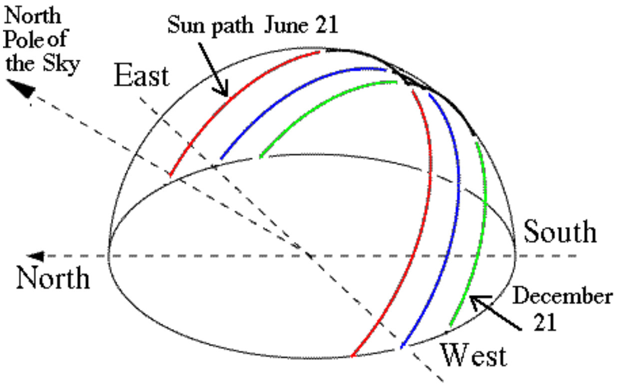


Fig3: Sun's apparent motion

During the day the sun appears to move across the sky from left to right and up and down above the horizon from sunrise to noon to sunset. Figure 1 shows the schematic above of the Sun's apparent motion as seen from the Northern Hemisphere. To keep up with other green energies, the solar cell market has to be as efficient as possible in order not to lose market shares on the global energy marketplace. There are two main ways to make the solar cells more efficient, one is to develop the solar cell material and make the panels even more efficient and another way is to optimize the output by installing the solar panels on a tracking base that follows the sun. The end-user will prefer the tracking solution rather than a fixed ground system to increase their earnings because:

- The efficiency increases by 30-40%
- The space requirement for a solar park is reduced, and they keep the same output
- The return of the investment timeline is reduced
- The tracking system amortizes itself within 4 years (on average)

In terms of cost per Watt of the completed solar system, it is usually cheaper (for all but the smallest solar installations) to use a solar tracker and less solar panels where space and planning permit.

V. SOLAR TRACKERS (BASED ON THE DESIGN OF PANEL)

There are many different types of solar tracker which can be grouped into single axis and double axis models:

Single axis trackers: -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. These have a manually adjustable tilt angle of 0-45 degrees and automatic tracking of the sun from east to west. They use the PV modules to themselves as light sensor to avoid unnecessary tracking movement and for the reliability. At night the trackers take up a horizontal position. This kind of tracker is most effective at equatorial latitudes where the sun is more or less overhead at noon. Due to the annual motion of the earth the sun also moves in the north and south direction depending on the season and due to this the efficiency of single-axis is reduced since the single-axis tracker only tracks the movement of sun from east to west. During cloudy days the efficiency of the single axis tracker is almost close to the fixed panel.

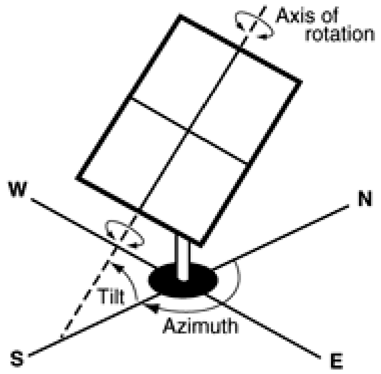


Fig 4: One axis tracking PV array with axis oriented South

Dual axis trackers: In dual-axis tracking system the sun rays are captured to the maximum by tracking the movement of the sun in four different directions. The dual-axis solar tracker follows the angular height position of the sun in the sky in addition to following the sun's east-west movement double axis trackers have both a horizontal and a vertical axle and so can track the sun's apparent motion exactly anywhere in the world. This type of system is used to control astronomical telescopes, and so there is plenty of software available to automatically predict and track the motion of sun across the sky. When the sun moves in the northern direction the tracker has to track the path of the sun in anti-clockwise direction along the horizontal axis (east to west). If the sun moves in the southern direction then the tracker has to track the path of the sun in clockwise

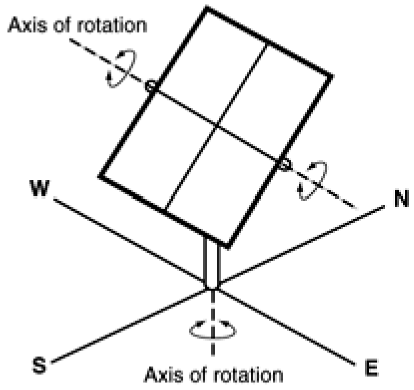


Fig 5: Two-axis Tracking PV Array

Dual axis solar trackers track the sun in both directions i.e. from east to west and north to south for added output power (approx 40% gain) and convenience.

VI. TRACKER COMPONENTS

1. Sun tracking algorithm: This algorithm calculates the solar azimuth and zenith angles of the sun. These angles are then used to position the solar panel or reflector to point toward the sun. Some algorithms are purely mathematical based on astronomical references while others utilize real-time light-intensity readings.
2. Control unit: The control unit executes the sun tracking algorithm and coordinates the movement of the positioning system.
3. Positioning system: The positioning system moves the panel or reflector to face the sun at the optimum angles. Some positioning systems are electrical and some are hydraulic.

Electrical systems utilize encoders and variable frequency drives or linear actuators to monitor the current position of the panel and move to desired positions.

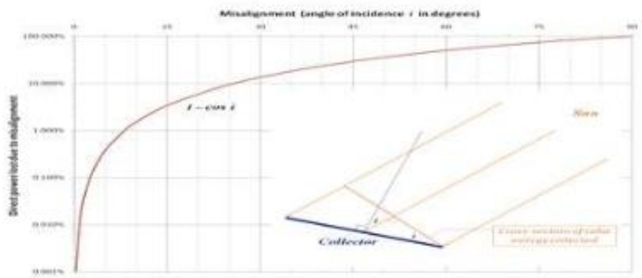


Fig. 6

The effective collection area of a flat-panel solar collector varies with the cosine of the misalignment of the panel with the Sun.

VII. RESULTS

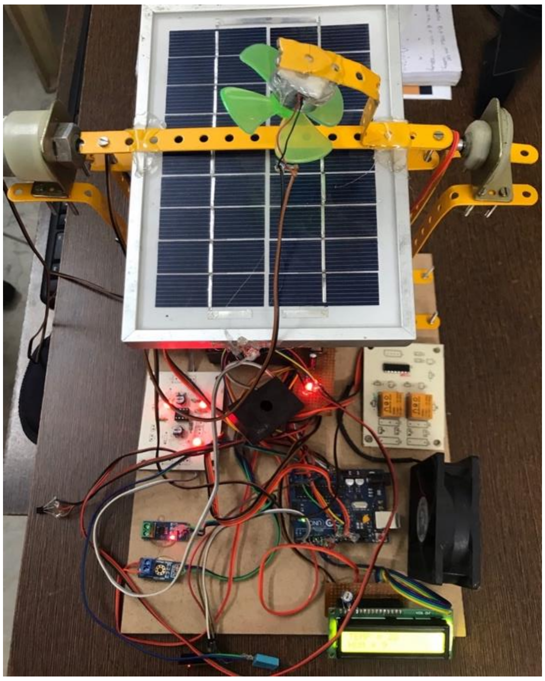


Fig 7: Solar tracker

Fig 8: Dust sensor readings

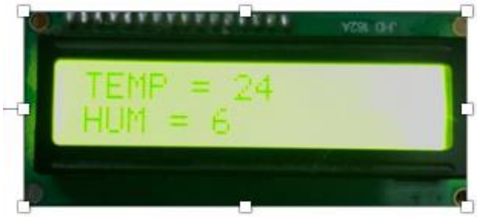


Fig 9: Temperature and humidity sensor output

Fig 10: LDR active

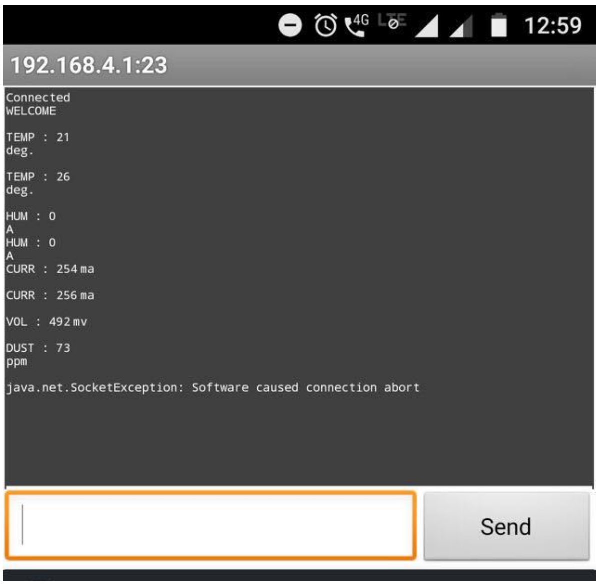


Fig: 12 output readings on Mobile screen through WIFI

VIII. CONCLUSIONS

Solar tracking mechanisms improve the energy gain of solar power plants. Automatic solar tracking system is generally the one that reaches the highest energy gain in every region. It is therefore the most versatile system, since it can be installed anywhere, guaranteeing a high energy gain. Solar trackers are recommended everywhere from an energetic point of view, since they always increase the amount of collected energy. Two degrees of freedom orientation is feasible. Arduino Uno controller is used to control the position of DC motors which ensures point to point intermittent motion resulting from the DC geared motors. Standalone working and wireless communication is achieved with computer or mobile which makes the system reliable and observable. The use of LDR sensors and high precision voltage and current sensor guarantees a more accurate and efficient tracking system. It now displays the sensors Parameters to the User over the internet Using effective application and also alerts user when sensors parameters above specific limits. This makes remotely monitoring of solar plants very easy and ensure best Power output.

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