IoT Based Dual Axis Solar Tracker with Power Monitoring System

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Abstract

The main goal of this project is to design an accurate solar tracker and share information through IoT. In this work, sensing of the sun position carried out in two stages, primary and secondary. Preliminary stage or indirect sensing performed via sun-earth relationship as a coarse adjustment and second stage or direct sensing performed via a 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 of the weather condition. The energy extracted from photovoltaic (PV) or any solar collector depends on solar irradiance. For maximum energy extraction from the sun, the solar collector panel should always be normal to the incident radiation. Solar trackers move the solar collector to follow the sun path and keep the solar collector's orientation at an optimal tilt angle. Solar tracking system improves the energy efficiency of photovoltaic (PV) panels substantially. The project is divided into two parts; hardware and software. Hardware parts generally composed of solar panels, two motors, an LDR sensor module, temperature sensor, humidity sensor and electronic circuit. The software part represents the thinking behaviour of the system. That is how the system acts under several weather conditions. This paper designs and develops an automatic solar tracking system using Light Dependent Resistor (LDR) and DC motors on a mechanical structure with gear arrangement. It is implemented through an Arduino UNO controller based on Sun-Earth Geometry. The results indicated that the automatic solar tracking system is more reliable and efficient than a fixed one.

Keywords: *- Arduino UNO, LDR, Photovoltaic (PV) panel, Solar Tracking System, Humidity Sensor, Temperature Sensor, Omni phobic material, IOT*

INTRODUCTION

Nowadays, climate change on the globe is at a critical level. Climate change can be divided into two categories, human and natural causes. Natural causes of climate change are ocean currents, solar variations, and orbital earth changes. The main parts of climate change caused by humans are man-made greenhouse gases. Global warming or climate changes can be seen through natural phenomena like the effect on crops and extreme weather conditions around the world.[20]

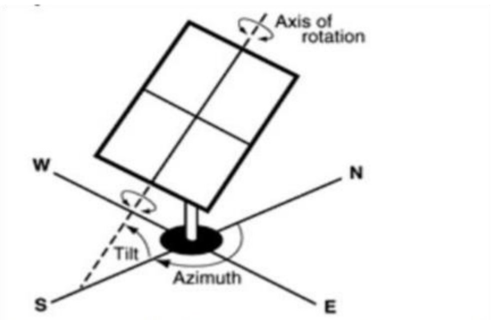
Renewable energy comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). Renewable energy is the best-growing energy source on the globe. Renewable energy is a source of energy that doesn't consume the earth's finite resources and can be easily and quickly replenished. Renewable energy plays a crucial role in a country's energy needs, enabling businesses to gather energy cost investments and revenue, thus controlling the outcome of climate changes.[20]

In Malaysia, oil and coal are the primary electrical energy resources for relatively long periods. Knowing that oil and coal will be reduced, the government started to decrease oil and coal usage as the main energy resources of electrical energy. It started an initiative to use other renewable energy such as solar and hydro. In Malaysia, residential energy use accounts for more than 14,365 GWh or 19% of the total electricity consumed in Peninsular Malaysia in the year 2006. The demand for electricity keeps increasing over the years, and solar energy is the alternative for those electricity problems. Solar energy is the energy derived from the sun through the form of solar radiation. The sun is the most inexhaustible, renewable source of energy known to man. Solar energy provides light, heat and energy to all living things. There is no price and no air pollution created by solar energy, which is environmentally friendly, and solar energies are interminable supplies. The developments of the solar tracker are applied in this particular project because Malaysia's climate is categorized as equatorial, being hot and humid throughout the year. As for solar energy, it is pertinent that it has many advantages and disadvantages when it comes to comparing other energy sources. The fundamental issue of utilizing solar energy is not a matter of lack of energy sources. Still, it is a matter of environmental concern as some conventional energy sources contribute high emissions to the environment.[11]

SOLAR TRACKER

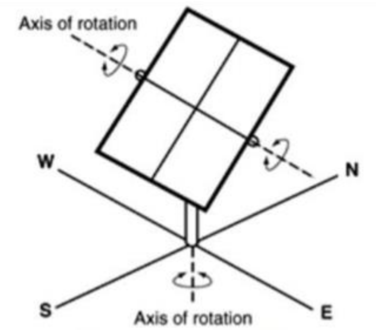
Sunlight has two components, the direct beam that carries about 90% of the solar energy and the diffuse sunlight that brings the remainder. The diffuse portion is the blue sky on a clear day and increases proportionately on cloudy days. As most of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible. A typical solar panel converts only 30 to 40 per cent of the incident solar irradiation into electrical energy. The two types of that are used maximum are:

A. Single-axis solar tracker: Single-axis solar tracker generally has only a single degree of freedom and can rotate from east to west. This tracker only considers the daily movement of the sun concerning earth position. A single DC motor is used to achieve a single degree of freedom. Despite being cost-effective and easy to build, a single axis solar tracker is less efficient than other trackers.



One axis tracking PV array with axis oriented South

B. Dual-axis tracker Dual axis tracker has two degrees of freedom, and it considers the daily movement of the sun (from east to west) and yearly movement of the sun (North to South). It generally consists of two DC motors to achieve two degrees of freedom. This tracker is challenging to build, but higher efficiency overcomes the difficulty in design.



Two-axis Tracking PV Array

LITERATURE SURVEY

For working in different weather conditions, use different strategies by which the tracking error of the usual tracking strategy is 0.15, so it could provide high tracking accuracy for the solar systems.[1]

One of the advantages of a dual-axis solar tracker is that solar energy can be collected more effectively at unfavourable locations and weather conditions than a single axis solar system.[2]

With an automated two-axis solar tracker, the average gain in the maximum power and efficiency obtained with the two-axis PV tracking system is 5.0423 W per hour and 28.87 %, respectively, compared to the fixed PV system.[3]

A report provided the information on using data logging in an automated solar tracker to store solar radiation, voltage, temperature onboard, design, and implementation.[7]

For working under different conditions, construction of a solar tracker following direct and indirect sensing system.

A study shows the implementation of a dual-axis solar tracking system using a 555 timer to construct a simple solar tracker with a rear sensor circuit incorporated to aid in repositioning the solar panels for the next sunrise.[18]

A dynamic feedback controller presented a solar tracking system consisting of open-loop tracking strategies based on solar movement models and closed-loop strategy.[13]

Using a systemic approach to capacity development for solar PV also addresses other domains, such as economic development and gender equality, which can impact the capacity for solar PV lighting. By providing knowledge and educating and employing people in rural areas.[14]

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 understand and appreciate the technologies associated with renewable energy. One of the most popular renewable energy sources is solar energy. Many researches were conducted to develop 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 RTC based solar panel tracking system. Solar tracking enables more energy to be generated because the solar panel can always maintain a perpendicular profile to the sun's rays. The 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 sun's location. The boards 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 using a tracking system over a fixed design can increase the power output by 30% -60%. The increase is significant enough to make tracking a viable preposition despite the enhancement in system cost. It is possible to align the tracking heliostat normal to the sun using electronic control by a microcontroller.

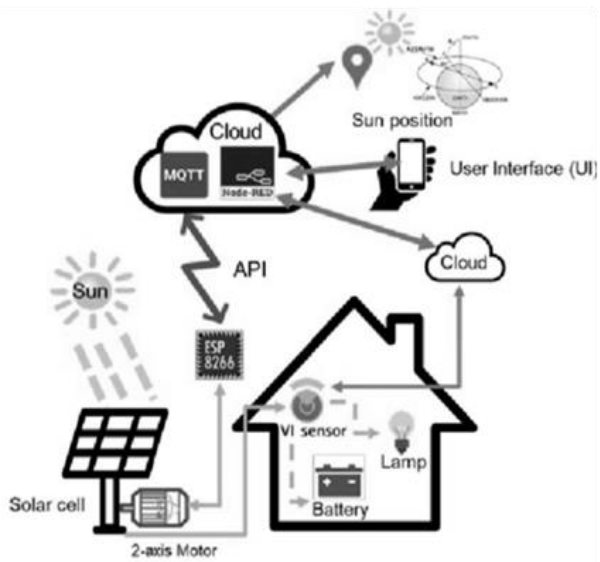
a) When the sun is up, the system must follow the sun's position in the sky.
b) This must be done with active control that involves helpful timed movements. It should be automatic and simple to operate. The operator interference should be minimal and restricted to only when it is required. The major components of this system are as follows.
    1) Solar Panel
    2) LDR’S
    3) Servo motors.
    4) Temperature & Humidity sensor
    5) Photovoltaic cells

7) Current sensor
8) Voltage Sensor
9) ESP8266 Wi-Fi Module
10) Omniphobic Material

The objective of the proposed system is to provide a dual-axis solar tracking system capable of tracking the sun in any weather condition more efficiently than the traditional methods, which are currently in use with less maintenance cost and more power generation capacity.

PROPOSED SYSTEMS

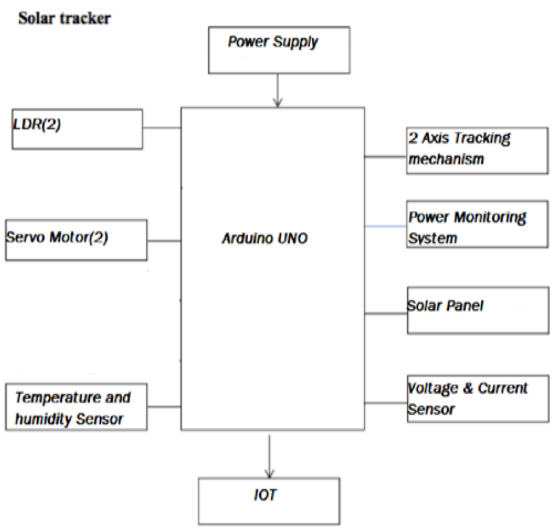
Solar power plants need to be monitored for optimum power output. This helps retrieve efficient power output from power plants while monitoring for faulty solar panels, connections, dust accumulated on panels lowering work and other such issues affecting solar performance. So here we propose an automated IOT based solar power monitoring system that allows for automatic solar power monitoring from anywhere over the internet. We use Arduino based system to monitor a solar panel.



Our system constantly monitors the solar panel and transmits the power output to the IoT system over the internet. Here we use IOT to transmit solar power parameters over the internet to IoT. It now displays these parameters to the user using an effective GUI and alerts them when the output falls below specific limits. This makes remotely monitoring solar plants very easy and ensure the best power output.

In our model, we added weather prediction, showing data online, temperature and humidity etc. Which are connected with a Wi-Fi module, and we can see all types of data on our mobile application. To protect the solar panels in dusty and windy conditions, a layer of omniphobic material will be applied to it, so it does not get damaged and maintenance costs and time get reduced.

Finally, the motivation of the research is to design and implement a hybrid dual-axis solar tracking system that reduces motor power consumption while tracking accurately. The microcontroller compares the light intensity, generating suitable control signals to move the motors in the proper direction.



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 realtime light-intensity readings.

2. Control unit:

The control unit executes the sun tracking algorithm and coordinates the movement of the positioning system.

1. 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 functions.

CONCLUSIONS

Solar tracking mechanisms improve the energy gain of solar power plants. An automatic solar tracking system is generally the one that reaches the highest energy gain in every region. Therefore, it is the most versatile system since it can be installed anywhere, guarantee a high energy gain. Solar trackers are recommended everywhere from an energetic point of view since they always increase 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 a computer or mobile, making the system reliable and observable. LDR sensors and high precision voltage and current sensors guarantee a more accurate and efficient tracking system. It now displays the sensors' parameters to the user using an effective application and alerts the user when sensor parameters are above specific limits. This makes remotely monitoring of solar plants very easy and ensure the best Power output.

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