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Design and Realisation of Automated Solar Tracking System

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Abstract: Solar energy is expeditiously gathering notoriety as an influential source for broadening the renewable energy resources. The trailing project will encompass the design and fabrications of a microcontroller based solar panel tracking system. Solar tracking system permits a lot of energy to be generated as a result of the uninterrupted sun rays which remains coordinated with the solar array. The continual modification within the relative positions of the sun and earth determines regular wavering of the incident radiation on the steady PV panel. Maximum energy is acquired at the position once the panel surface is straight to the solar radiation. Hence, the maximal result potency of a given PV panel may be derived by mounting the panel over a tracking device which would follow the trajectory of the sun. Time based sun's radiation tracker adapts the most desirable position of the panel based on time with the assistance of the servo motor connected to it.

1. INTRODUCTION

If any phrase were to be used to describe the time in which we are living, it would be "renewable energy." For ages now, this term has caused many businesses to design and manufacture products in efforts of promoting this phrase.

Country like India has very much unbalanced in electricity production.

India's plan to become the world's largest solar power markets has received a massive boost as its latest solar energy potential is estimated.

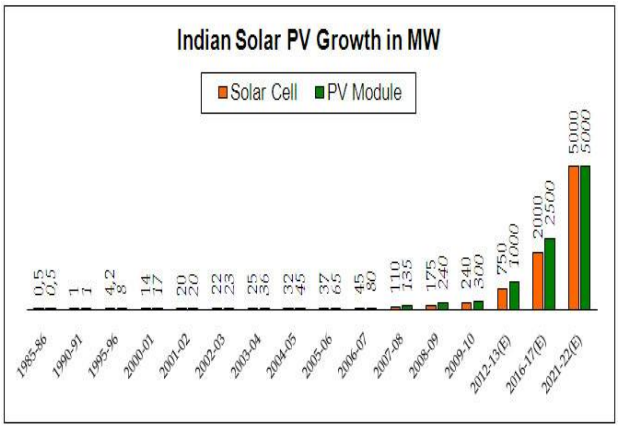

Figure 1. Statistics of Indian Solar PV Growth

The present systems do not provide a cost-efficient and reliable method to generate and operate renewable energy for common uses. The various renewable energy that are of consideration include solar, wind, thermal, geothermal, and nuclear energy. This brings up the need to push for ward the research and methodologies for the optimum energy generation. Solar is the fastest growing source of electricity with an approximately 40 percent growth annually over the past decade. This growth is due to the abundance and availability of solar energy.

Greater advancements have been proposed to improve the efficiency of the current solar power systems. It has been proved that 37.57 minutes of the total solar radiation received by earth, if harnessed, is enough to provide the world with the electricity requirements for one complete year. However, such technologies are not available, and it is not possible to install solar panels at every part of the planet. Solar tracking systems are panel-based systems that are meant to follow the direction of sunlight in order to harness maximum power. Manual solar tracking was the basis of such systems. However, this was too cumbersome. Automatic solar tracking systems have been proposed in the aim to reduce the human intervention in such systems and make the more reliable. An automatic solar tracking system involves a microcontroller-based system in order to automate the process of alignment of panel in a direction perpendicular to the sun rays. Solar tracking can be of two types:

- Single-Axis Tracking
- Dual-Axis Tracking

Single axis tracking involvesss calculations and optimization only along azimuthal angle. Although such a system a need for a better system also exists. Taking into account the variations of sun rays, along altitude angle, a dual axis tracking system comes into picture. This system turns out to be more efficient than the previous systems. In this project, we aim to demonstrate such a dual-axis solar tracking system using low cost microcontroller.

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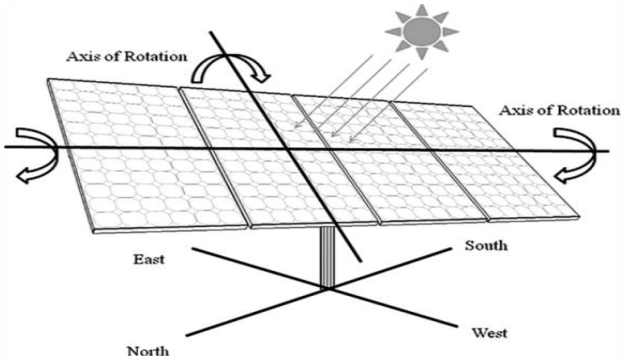

Figure 2. Schematic Diagram of Dual Axis Solar Tracker

2. LITERATURE REVIEW

There are numerous models for solar tracking system and their performance and feasibility have been studied by many researchers.

Zhanet al. [1] proposed a dual axis solar tracking system using a PLC based system that involved a feedback through the light sensors as the input to the controller. The feedback system was made to provide the panel with a control signal and a corresponding rotation of motors is provided. Such a s system, provided an efficiency increase of 17-25 percent on sunny days as compared to fixed-angle systems.

Gutiérrez[2]explored the chance of rising energy production without adding additional photovoltaic modules .This can be achieved by implementing the tracker with only north-south axis with an optimum tilt to simplify the mechanical design as compared to double axis tracking system. In order to simplify the electrical control the movement of the actuator is divided into 10 steps rather than endless movement.

Malgeetal.[3] proposes a special type of system in which feedback has been provided using ARM processor BeagleBone Black- BBB, light dependent resistors and servo motors. The facility of internet provided by BBB allows the users to monitor the solar tracking in real time. This system allows the user to keep an eye on the solar panel from anywhere in the world. Even if any part of the tracking system gets damaged, the user will get this information instantly and can replace the damaged product, thus making the whole system more efficient.

Pacis[4]This paper aims to increase the efficiency of outdoor lighting system which gets power from sun by using dual axis solar tracking. The system also uses maximum power point tracking (MPPT) charge controller to locate the maximum power from sun. Two pair of LDR's are used to detect difference in voltage which is fed to microcontroller. The microcontroller used to rotate the DC motors is an Arduino with a processor of ATmega644.The performance of standalone system and dual tracking system were compared and around 30% change in output power was observed.

Anita[5] focuses on electricity generation from solar panel by keeping the panel in vertical position so that less space is occupied. Here a chronological dual axis solar tracker was implemented by using astronomical information of sun's position throughout the year. In this system Arduino UNO microcontroller is used which is programmed with astronomical information of sun's varying positions or any location. Arduino gives the signal to stepper motor which rotate the panel in direction of maximum sunlight. The system faces the problem of shadow impact and work is going on to avoid this.

Jing-Min Wang et al. [6]presents a methodology for the use of LDR based system for tracking sun basically based on closed loop system hence developing an optical sensor. Here LDR's are not directly attached to the solar panel but on an external board that gives a better control to the complete solar tracker unit. This was the novelty of the project, other components used are a solar panel and a solid wooden bar that will cause a shadow and will lead to working of this model.

3. PROPOSED SYSTEM ARCHITECTURE

The paper was carried out with the following objectives:

a) To identify challenges with the present solar power generation systems.

b) To model the proposed tracking scheme and compare it with the present systems.

c) To construct working model of tracking system with maximum accuracy and efficiency.

d) To implement the system in rural areas for healthcare.

Figure 3. Solar panel

Today, it is an urgent need to move from conventional resources to non-conventional resources. However, the present technologies do not harness the complete poten-

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tial of renewable resources. This is of major concern when solar energy comes into picture. There is enough solar radiation to provide sufficient electricity to whole of the planet. However, certain hardware and material modifications need to be done in order to utilize it properly. The proposed system helps in capturing more light by the photovoltaic cells, using a tracking algorithm, thus generating more electricity.

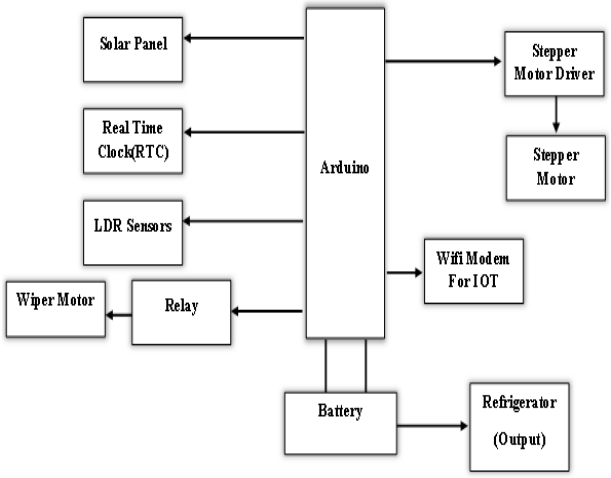

Figure 4. Block Diagram of the Prposed System

In this paper, RTC(real time clock) is interfaced with the arduino uno microcontroller to manage the perpendicular profile with the rays of the sun. This is done by the microcontroller which is programmed to rotate the stpper motor in accordace with the sun's position estimated by RTC. The uniqueness of this system is the usage of LDR sensors and RTC together for better explicability. LDR is used as a sensor in this project. It calculates the volatge output and intimidates it to the WiFi module which stores it as a database in the IoT cloud. The ESP8266 is a low-cost WiFi micro chip with full TCP / IP stack and microcontroller capability for further analysis and modification of the output database from the LDR sensing unit. This project also comprises an automated solar panel system for self-cleaning. The panel detects the presence of powder and actuates a cleaning mechanism that cleans it and thus restore the panel to its normal capacity. It is done at the end of the day with a wiper motor connected to the relay system.

1) Arduino Uno : Arduino Uno Arduino UNO microcontroller is used which is programmed with astronomical data of sun's varying positions or any location. Arduino gives the signal to stepper motor which rotate the panel in direction of maximum sunlight. To reduce the cost of the system; Arduino Uno singleboard microcontroller is used.

2) Real time clock(RTC):A real time clock (RTC) is a computer clock (most often in the form of an integrated circuit) that tracks the sun's current position using the sun path diagram.

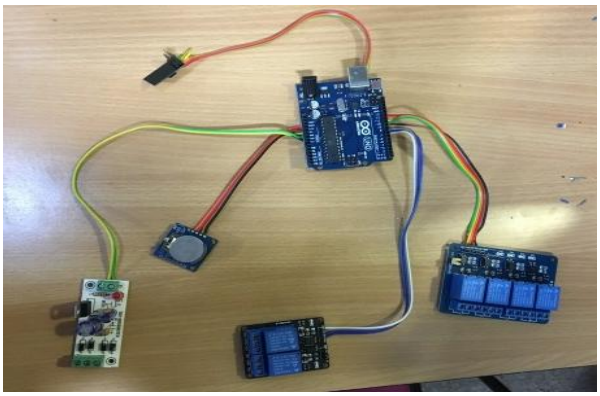

Figure 5. A RTC based arduino system

3) Motor driver (L298): The dual bidirectional motor driver is based on the popular L298 Dual H-Bridge Motor Driver IC. This module allows you to control two motors up to 2A in both directions easily and independently.

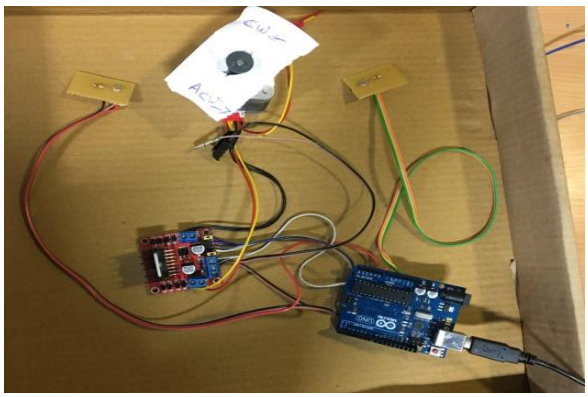

Figure 6. Stepper motor circuit based on LDR

4) Light dependent resistor(LDR) : In this LDR is used to measure the intensity of the sun rays.The LDR is connected to Arduino's analog pins via voltage divider circuit using variable resistor so that the sensor or arduino does not gets damaged in jp board.

5) WiFi modem(ESP8266): ESP8266 with 1 MiB built-in flash that allows single-chip devices to connect to Wi-Fi that can be used for data storage in the IoT cloud.

6) Wiper System: Wiper System: A simple wiper system is used to clean solar panels that cause significant power loss.

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4. METHODOLOGY

An algorithm developed with microcontroller using real-time clock time is used to adjust position of solar panel with the help of dc motor. In this method a relationship is developed between time and sun position with experiments in day time. Thus, according to the position of the sun rays the panels get automatically adjusted by the motor system allowing the sunrays to fall upright on the PV cells. In this manner the PV cells generate maximum productivity.

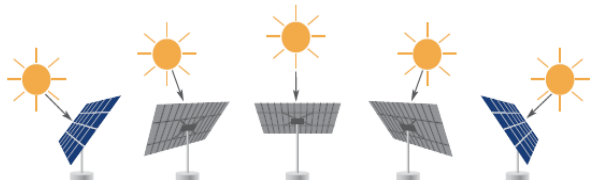

Figure 7. Position of Solar Panel based on sun rays

Meanwhile, the LDR sensing unit will measure the intensity of sunlight constantly. The ESP8266 will be used to measure the voltage sensed by LDR and send it to Easy-IoT Cloud hence allowing us to analyze the data for a better performance.
Wiper system is used to clean the panel on the regular basis to generate the same amount of power in the longer term. Hence, fabricating a viable structure.

5. OUTPUT

The main advantage of this system is that it is portable and has low maintainance cost. Also, there is a continuous output analysis improving it's accuracy as well as efficiency. This viable system can be used in many fields such as agriculture, public welfare, healthcare along with personal use.

Figure 8. Healthcare campaign in rural India

Due to lack of knowledge, neglectance and unavailability of resourses, the healthcare facilities could not penetrate in rural areas of India. This is leading to the continuous detoriation of the medical provisions. One among many problems is the improper storage conditions for medicines and vaccines, because they require an optimum temperature to retain. This improvised solar system due to it's portibility provides a potent medical provision for the problem.

Figure 9. Medicament storage

The generated system output will be used to drive a portable refrigerator providing a suitable temperature for the required medicament. Temprature is adjustable according to the need of the vaccine. Hence, this system can be an aid to the underdeveloped grassroot levels of India for their upliftment. By this means we can improve the quality of life of rural people which these days is an important agenda of rural development programme.

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