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Automated Dual Axis Sun Tracking Solar Panels based on LDR and RTC Sensor

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***Abstract*:- Energy crisis is one of the most crucial topics in today's world. Conventional energy resources are not only limited and costly, but also the prime cause for environmental pollution. The environmental pollution and rising cost of the fossil fuels have drawn considerable attention to renewable energy sources. Solar energy, being the cleanest and most reliable renewable energy source, is widely utilized in thermal systems to heat water and air. It offers a vast opportunity for public and private organizations to reduce carbon emissions and cut electricity costs. A viable approach to maximizing the solar panel efficiency is solar tracking. Many of the solar panels throughout the world are positioned with the fixed angles. To maximize the use of the solar panel we use a solar tracker which orients itself along the direction of the sunlight. The solar tracker positions the panel in a hemispheroidal rotation to track the movement of the sun and thus increase the total electricity generation. This paper focuses on the development of new approach to control the movement of the solar panel. The purpose of this paper is to simulate and implement the most suitable and efficient control algorithm on the dual-axis solar tracker which can rotate in azimuth and elevation direction. The simulation gives the tracker angles that position the solar panel along the sun's rays such that maximum solar irradiation is absorbed by the panel .This paper therefore proposes an automatic version of dual axis suntracking solar panels using LDR and RTC sensors.**

1.INTRODUCTION:

Industrial-scientific technology is continuously evolving to pursue practical solutions to continuous demand in the energy fields and mechanical engineering. Recently, a significant trend in the production of renewable energy has been made via proposing several inventions, technical, mechanical and material alternatives. Solar energy occupies an important part in energy generation and scientific research, which seeks to increase and improve production. Energy has been essential for the development of society over time. The increase of energy consumption since the industrial revolution has led to concerns associated with environmental impacts and resource depletion, particularly because most of the energy originates from fossil fuels such as oil and coal. Fossil fuel depletion and global warming are the two most important concerns for the sustainability of energy systems in the future .
Energy dependence, the limitation of fossil energy sources, and the negative environmental impacts of fossil fuels have directed researchers towards renewable energy sources. The efforts to reduce the use of fossil fuels and greenhouse gases emissions, related to electricity generation, have been leading to a fast increase in the development of renewable generation. Finding energy sources to satisfy the world's growing demand is one of the foremost challenges for the next half-century. Over the recent years, greenhouse effect has caused global warming and irregular climate changes. To generate electricity, few countries still depend on fossil fuels which produce greenhouse gases that can severely impact human and wildlife population. Environmental pollution and rising cost of the fossil fuels around the globe rouse individuals to concentrate on renewable energy sources. As per scientific predictions, the consumption of fossil fuels will decrease by 80% and of non-fossil fuels will increase by 50% within a period of 30 years. Statistics has shown that available fossil fuels will deplete by 2080. Thus, the primary energy source has to be non-convention sources . The earth receives 16x1018 units of energy from the sun annually, which is 20,000 times the requirement of mankind on earth . On a sunny day, energy radiated from the sun is about 1 kW/m2. As mentioned in , "the International Energy Agency predicts that approximately one-quarter of the renewable power, or 11% of worldwide electricity, could be supplied from solar energy in 2050."
This paper therefore, aims to optimize the harnessing of solar energy by use of dual axis sun tracking solar panels based on LDR and RTC.

1.1 LITERATURE REVIEW

Number of people have collected data and analyzed about sun tracking solar panels. There are many useful articles we anlysed for this.

1. The paper [1]shows that a new thermo-mechanical design of sun tracker using smart materials integrated in photovoltaic system has been proposed. The proposed design intends to model the SMA actuator as sun tracker that combines with a PV system. The mathematical modelling described the SMA actuator behaviour that responding to thermal energy (sun energy). Besides, the study presented the mathematical equations of the produced power by a solar PV system, which can be used to identify improvement occurred in energy production and can be compared the results in solar systems with and without tracker. In order to validate the proposed study, a numerical comparison has been made between the simulation results and literature. A significant improvement of energy production using the integrated solar tracker has been shown. Consequently, the energy efficiency of the PV system is evidently improved using SMA tracker compared with the fixed PV system. In fact, the power efficiency of the proposed tracking system has increased about 39% for sunny day. In case of unstable weather, the solar system remains safe due to the SMA actuators that surround it. As a result, wherever sunlight falls, it activates the part of the actuators facing it, which changes the inclination angle

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of the system. Additionally, the presented sun tracker has many advantages as simplicity movement, reducing energy consumption, working under different perturbation conditions (wind, rain, important temperature variations), working in a water environment, exerting large strain, tracking as a natural mechanism system, having a long fatigue life.

2. The paper [2] shows that The gains generated by the tracking mechanism were more substantial on sunny days or on days with few clouds. On cloudy or rainy days, this gain was observed to be reduced and sometimes slightly negative in cases when the panel was stationary owing to the luminosity below the limit. During the period of one day, this increase is less than or equal to zero at midday, increasing as the time distances from this period, during the morning as well as in the afternoon. Furthermore, the tracking panel reduces the losses caused by the curve trajectory of the Sun, which starts and ends at the back of the fixed panel. This type of losses in the fixed panel can be observed in the months of October and November, when the average daily irradiations are lower than those in the previous months. Considering the period from June to November, the irradiation data were collected on a panel mounted on a fixed structure and another one equipped with tracker mechanism. During all months,the tracking panel presented irradiation gain over the fixed panel,ranging from 17.2%, in June, to 31.1%, in November. At the end of the period of analysis, the period being a total of 152 days, the tracking panel obtained an average gain of 23.4%, considering the proportion of rainy or cloudy days as 40%.

3. The paper [3] shows the design of the phase compensation for solar panels with experimental status and required graphs. The compensation for solar panel systems in order to tracking sun has been studied and represented in its equivalent closed loop control system. These systems improved the performance of solar panel systems to produced maximum power efficiency. The response of this controlled system showed sluggish performance. Therefore, it is necessary to introduce proportional derivative integral (PID) controller and (Lead-Lag) phase compensator to improve the dynamic response of the system. The required specifications are to obtain faster response with the minimum peak over shoot (Mp). The closedloop system is initially built in Simulink / Matlab package and the (PID) controller and (Lead-Lag) phase compensator has been build into special subsystem. The components of control system have been dragged directly from Simulink library. Results showed that when compensator is properly designed the response would be acceptable in the sense of required specifications.

4. The paper [4] shows the average voltage readings for active and chronological algorithms for six days. It can be found that the chronological algorithm excels over the active algorithm on cloudy weather or when the active output voltage is below 11 V. Conversely, the active algorithm can yield high accuracy during sunny day but not on cloudy days, which may be attributed to low LDR sensitivity .With graphical representation.

5. The paper [5] shows the development of new approach to control the movement of the solar panel. The purpose of this paper is to simulate and implement the most suitable and efficient control algorithm on the dual-axis solar tracker which can rotate in azimuth and elevation direction. The simulation gives the tracker angles that position the solar panel along the sun’s rays such that maximum solar irradiation is absorbed by the panel.Also to maximize the power generation the required formula is derived.

6. The paper [6] shows The demand for power has been on the increase and so has research to utilize renewable energy, hence the need to maximize on available sources by improving the technologies. A smart single axis solar tracking device was developed and tested, the results of which showed a 25% increase in efficiency hence a successful design within the objective budget of USD150.00. The tracker, developed from readily available and maintainable materials can track sunlight from sunrise to sunset. The prototype only served as confirmation of this design with the experiments that were performed showing an increase in efficiency and power produced. This design can be implemented on a large scale with sufficient funding to produce an even better solar tracker to rival the existing ones on the market. As the demand for energy increases while more users explore renewable energy technologies, this research has the potential of augmenting other means of improving and availing such technologies to industrializing countries such as Zimbabwe with an abundant exposure to sunlight but frequently covered by clouds. The use of such devices also helps to sustain the tapping of renewable energies and thus reduce the demand for power from erratic supplies from the national grids.

7. The paper[7] shows It could be concluded that the proposed scheme does optimize solar energy extraction. By comparative study, which shows an increase of energy extraction by about 40% over fixed panels. The study has also showed the big advantage of the optimized scheme over continuously rotating panel. In fact it was found that the energy saving on the consumption side is just over 20%. More importantly during the peak hours where maximum energy is extracted, the panel only rotates for a handful times (in the case in hand only three times). On top of that the beauty of the scheme is that only a single tiny PILOT, drawing very small current, could be used to guide thousands of panels. As a general conclusion, with the big progress in the cell design where it is on the verge of 50% efficiency mark together with a good optimum panels orientation like the one proposed here, with the saving on the energy consumption, the future of solar energy extraction looks very promising indeed.

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8. The paper [8] shows an overview on the advancements in the work of the solar tracking systems in the world and it emphasizes on the performance analysis of dual axis solar tracking systems equipped with different designs and techniques which have been evolved in recent years. Dual axis solar tracking systems generally prove to be more efficient than single axis and fixed counterparts. These systems also demand maintenance due to the presence of rotating components. These systems contain more complex design and control mechanism. The performance of the solar system depends on many physical factors and so does the choice of use of tracking.

9. The paper [9] shows This study has compared the voltage, electric current, power, and efficiency of a solar tracking system using two and four-sided flat-mirror reflectors with angles of 90◦, 120◦, and 150◦ between the solar panel and solar flat-mirror reflectors. The electrical current, power, and efficiency of the four-sided flat-mirror reflector system were better than those of the two-sided flat-mirror system only when there was a suitable angle (120◦) between the reflector flat mirrors and the solar panel due to the higher solar ray input. The two-sided flat-mirror reflectors were better than the four-sided ones at 90◦ because the extra two flat mirrors in the case of the four-sided flat mirrors blocked some of the solar rays. At 150◦, the two-sided flat mirrors were also better than the four-sided ones because the angle of the flat mirrors was too big for the solar rays to be reflected to the solar panel. Use of flat mirror for better power generation.

10. The paper [10] shows that It is almost unanimous that single axis tracking is better than stationary panels. And dual axes tracking is better than both either the stationary or single axis tracking. Though there is no unanim- ity of the improvement where it was reported that the increase in energy extraction varies between 12 and 69%; though it looks 69% is exaggerated. But the issue in tracking using either single or dual axes does not necessarily mean accurate tracking nor more harvested energy. Almost all the reported techniques are based on LDRs. But LDRs are voltage based, and tracking system are very sensitive to voltage. An accurate and very sensitive technique is the use of light to frequency conversion due to the fact the fre- quency is directly proportional to irradiation. That means it is di- rectly proportional to power, primarily current. The LTF also con- tributes in synchronizing between both the PILOT and PANEL with- out the need to use external switches. On the energy side and in some case, it has the opposite effect, where more energy is con- sumed by the driving motors and mechanical gears than the gen- erated energy. Unfortunately, both problems were not addressed previously. They were addressed in this paper where the user can determine the frequency and where the panels should move based on a pre-programmed pre-set threshold. This pre-set is user de- fined. The study has also shown that it is not necessary to track the altitude angle in areas on either side of the equator continu- ously where the altitude angle does not exceed the 30 °like our area (Bahrain), but it would be better to do an off-line tracking where four to eight movements of 8 °to 10 °each per year are largely sufficient and more than 98.36% extraction could be har- vested compared to continuous tracking. Most importantly, it was shown that the proposed scheme saves more energy than the pre- vious studies. It is also worth mentioning that the proposed PI- LOT scheme is useful because it could guide one panel the same as guiding thousands without any extra energy.

1.2 COMPARATIVE STUDY

SOLAR TRACKERS: Solar tracker is a device which is used to collect the solar energy emitted by the sun. Solar tracking is Nothing but changing position of panel With respect to sun. usually photo voltaic module assembled in solar tracker is more powerful than critical irradiance in the fixed system. Solar trackers are classified on basis of performance, coast respectively. by tracking system we can catch 40-50% more efficiency compared to fixed panel. Among them dual axis provides increased efficiency of 48% as compared with single axis tracker. Advantage of Dual axis trackers are catcthing the position of the sun any where in the sky due to seasonal variations. The following figures represent solar tracking systems. The main aim of this proposal is to implement high efficiency solar tracker.

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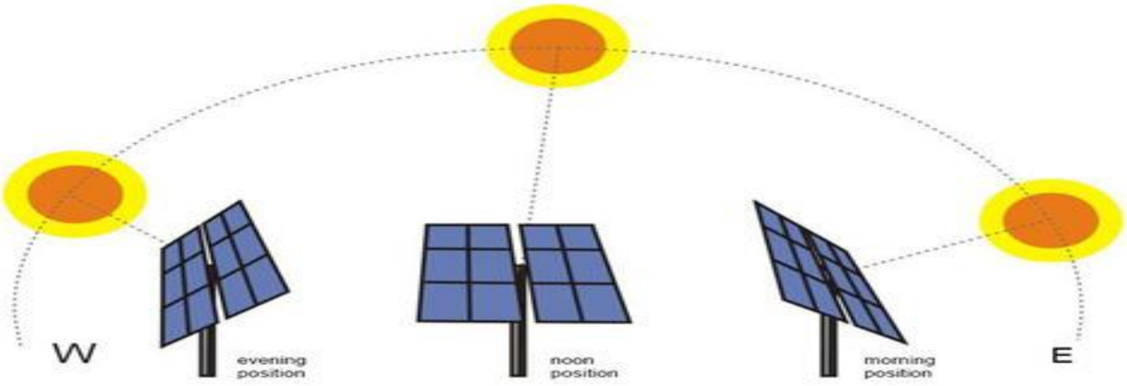


Types of solar tracking system : 1. Single axis solar tracking system
2. Dual axis solar tracking system

What is Dual axis solar tracking system?

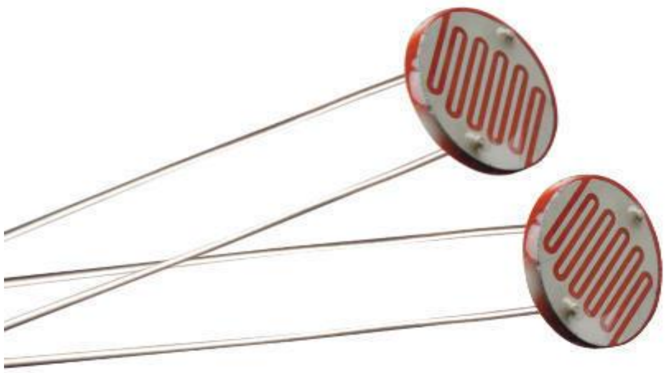
To track the sun in two directions that is elevation and azimuth, a **dual-axis tracking** prototype is developed to capture the maximum sun rays by **tracking** the movement of the sun in four different directions. One **axis** is azimuth which allows the **solar** panel to move left and right.

In this particular article we are using Dual axis solar tracking system.

1.3 HARDWARE REQUIREMENTS:

Since it is hard ware based project the main components are LIGHT DEPENDENT RESISTORS(LDR), Servo motors, Arduino as main controller.

- ***A . Light Dependent Resistor(LDR)***
- LDR are also named as photo conductors (or) photo resistors. Which works on the principal of photo conductivity. ldr resistance decrease with increase in light intensity and vice versa. LDR s are mainly used for sensing purpose in order to catch the solar energy and provide analog input to Arduino .



- ***B .Servo motor***
- Servo motor is three wired dc motor which works on the principal of servo mechanism. servo motor can rotate upto maximum angle of 180degrees. In our proposed project 4.8V motor is used. Since it is dual axis system two servo motors are used for east-west and north-south directions respectively. Servo motors are powered by PWM output received from the Arduino .

C .Solar panel

Solar energy is the photovoltaic cell which convert light energy received from sun into electrical energy. The name behind "solar" panel is they grab high powerful energy emitted from the sun. The solar panel finds its applications in street lights , domestic and industrial areas.

- ***D .Arduino***
- Arduino is the type of microcontroller. The purpose of microcontroller is to control the position of motor. so At mega 328p microcontroller is used. Arduino consist of 6 analog inputs and 14 digital i/o ports out of them 6 acts as pwm signals. In addition to this it consist of 16 MHZ crystal oscillator, a USB cable through which program is dumped. And Arduino get powered by the power jack. Advantages of Arduino is low cost, roubst construction and platform independent.

E. RTC Sensor:

Real Time Clock (**RTC**) is used to track the current time and date. It is generally used in computers, laptops, mobiles, embedded system applications devices etc. In many embedded system, we need to put time stamp while logging data i.e. **sensor** values, GPS coordinates etc.

It needs to be further programmed to track the path of the sun .

2. IMPLEMENTATION:

- The principle of the solar tracking system is done by Light Dependant Resistor (LDR). Four LDR's are connected to Arduino analog pin AO to A4 that acts as the input for the system. The built-in Analog-to-Digital Converter will convert

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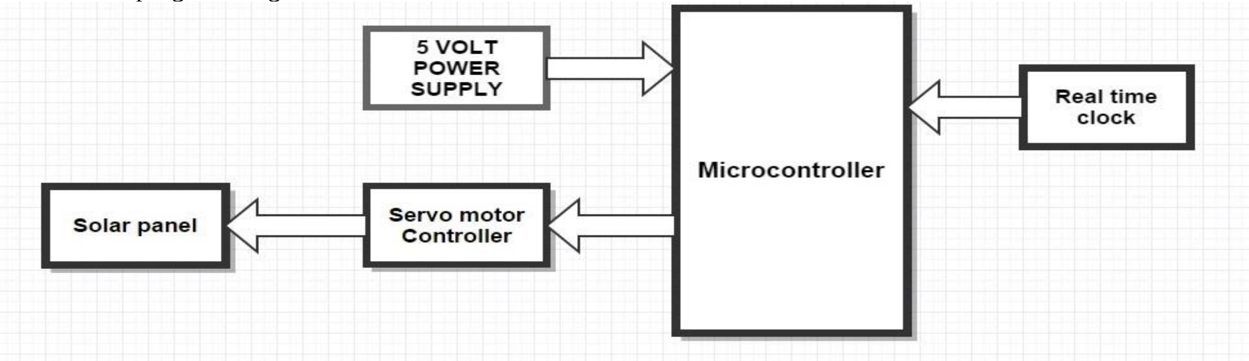
the analog value of LDR and convert it into digital. The inputs are from analog value of LDR, Arduino as the controller and the DC motor will be the output. LDR1 and LDR2, LDR3 and LDR4 are taken as pair .If one of the LDR in a pair gets more light intensity than the other, a difference will occur on node voltages sent to the respective Arduino channel to take necessary action. The DC motor will move the solar panel to the position of the high intensity LDR that was in the programming.



The RTC sensor needs to be programmed using Arduino Following is the program

```
#include <Servo.h>
Servo horizontal; // horizontal servo
int servoh = 180;
int servohLimitHigh = 175;
int servohLimitLow = 5;
// 65 degrees MAX
Servo vertical; // vertical servo
int servov = 45;
int servovLimitHigh = 60;
int servovLimitLow = 1;
// LDR pin connections
// name = analogpin;
int ldrlt = A0; //LDR top left - BOTTOM LEFT <--- BDG
int ldrrt = A3; //LDR top rigt - BOTTOM RIGHT
int ldrld = A1; //LDR down left - TOP LEFT
int ldrrd = A3; //ldr down rigt - TOP RIGHT
void setup(){
horizontal.attach(9);
vertical.attach(10);
horizontal.write(180);
vertical.write(45);
delay(2500);
}
void loop() {
int lt = analogRead(ldrlt); // top left
int rt = analogRead(ldrrt); // top right
int ld = analogRead(ldrld); // down left
int rd = analogRead(ldrrd); // down right
int dtime = 10; int tol = 90; // dtime=diffirence time, tol=toleransi
int avt = (lt + rt) / 2; // average value top
int avd = (ld + rd) / 2; // average value down
int avl = (lt + ld) / 2; // average value left
int avr = (rt + rd) / 2; // average value right
int dvert = avt - avd; // check the diffirence of up and down
int dhoriz = avl - avr;// check the diffirence og left and rigt
if (-1*tol > dvert || dvert > tol)
 {
 if (avt > avd)
 {
 servov = ++servov;
 if (servov > servovLimitHigh)
 {servov = servovLimitHigh;}
```

```
}
else if (avt < avd)
{servov= --servov;
if (servov < servovLimitLow)
{ servov = servovLimitLow;}
}
vertical.write(servov);
}
if (-1*tol > dhoriz || dhoriz > tol) // check if the diffirence is in the tolerance else change horizontal angle
{
if (avl > avr)
{
servoh = --servoh;
if (servoh < servohLimitLow)
{
servoh = servohLimitLow;
}
}
else if (avl < avr)
{
servoh = ++servoh;
if (servoh > servohLimitHigh)
{
servoh = servohLimitHigh;
}
}
else if (avl = avr)
{
delay(5000);
}
horizontal.write(servoh);
}
 delay(dtime);
}
```

3.CONCLUSION:

The use of both LDR and RTC sensor makes it easy to track the sun path. LDR sensor is used when there is no obstruction between sun and solar panels the intensity of light decides the position of the solar panels because LDR sensor reacts to intensity of the light. And when there is cloudy weather the RTC sensors comes into action ,programmed RTC sensor positions the solar panel as the path of sun is stored in the program and micro controller controls the sensors. Dual axis gives ease of rotation of solar panels.

4.FUTURE SCOPE:

This type of solar panels are the future of humans. As in remote areas electricity is yet to be introduced
Solar panels can be provided to the remote areas so that electricity can be used everywhere. As solar enegy is a renewable form of energy power will be generated by any means.

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