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Performance Analysis of Multi Axis Solar Tracker using Ardiuno-Uno based Micro-Controller

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***Abstract*— Solar energy is the most widely utilised renewable energy. In contrast to fixed solar panels, through solar-tracking system, they can harvest an abundant amount of energy hence, the solar panel's workability much added efficient. The efficiency of the solar panel is due to its perpendicular proportionality with the sun's rays that fall on the surface. The extraction of solar energy can enhanced by tracking the solar radiation with its time and further can improve the efficiency by surface dust cleaning of the solar panel. During rainy season hailstorm may damage the solar panel, this can avoided by providing the panels in the form of petals and can be closed and safe guard once the rain starts. Solar tracking, dust cleaning, opening and closing the petals can be easily controlled by using proper sensors and controller. This report contains information about the design and construction of multi axis solar tracker and this kind of Innovative prototype model can be developed for residential purpose. The Arduino-uno based microcontroller is used in the main control circuit of tracking unit. Sensors like light sensor, rain sensor and time sensor are used to send signals to microcontroller to control the activities. The programming of this system is performed in such a way that the Light Dependent Resistor(LDR) sensor, in response to the detection of solar radiations, directs the DC Motor in which direction the solar panel will rotate according to sun movement. The solar panel is then mounted in such a way that it receives the greatest amount of sun rays possible. Tracking solar radiation improves in the extra projection of the panel to the sun with enhanced energy production.**

***Index Terms*— Solar panel, Tracking system, Arduino Uno, LDR sensor.**

I. INTRODUCTION

Solar energy is a most important renewable, non-conventional, sustainable energy source that has high potential to help making to overcome many challenges. It is seen that the solar power gaining more popularity because of its flexibility and quite a lot of benefits to people and the world. Owing to disrupted weather patterns, climate change has resulted in a real problem, with a rise in floods and hurricanes. Oceans are becoming acidic as a result of high CO2 levels in the atmosphere, which is destroying marine life. Increase in atmospheric temperatures cause polar ice caps to melt, increasing sea levels and also effect on animal habitats. Droughts and irregular rainfall have an effect on agriculture and the livelihoods of the below poverty people in all over the world. Solar energy has the potential to mitigate climate change. In order to reduce the carbon footprint, solar energy is the best alternative solution because of its, clean, pollution free and abundant availability, hence it

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can reduce the combustion of petroleum-based fuels for energy production that leads to environmental pollution Photovoltaic cells (PV) can be used to harness solar energy. They can directly convert incident solar radiation into electric energy without affecting the environment. Hence, they are reliable and long lasting [1]. The major component of solar cell is silicon (Si). Silicon is a semi-conductor material. It is doped with certain impurities to make it a good conductor. When solar radiation hits the PV cell, the electrons are freed from the atoms, generating a flow of electricity. A group of solar cells harvest solar energy into a useful amount of direct current (DC) electricity. Solar panels arranged in series connection increase the output voltage. Series connected solar cells form a solar PV module. The extraction of solar energy into electric energy also depends on the angle at which the panel is fixed or made to rotate. Conventional solar panels are inefficient due to their fixed position and thus sun tracking system is used to absorb more amount of radiation [2]. There are two types: Single axis and dual axes tracking system. Since the sun is a constantly moving target, a single axis tracking system tracks the sun from east to west direction using a single pivot point to rotate. The axis of rotation can be horizontal or vertical or oblique. With a dual axis solar tracker, panels will always be oriented towards the sun, thereby maximizing the power generation [3]. Solar tracking can be control automatically by using the microcontroller like Arduino uno with additional sensors [4,5].

The percentage of energy extracted by solar panels with tracking can increases from 15% to 50% better than the fixed system. Mustafa Hamid Al-Jumaili et.al studied multi axis solar tracking system with Arduino Uno microcontroller and also used Light Dependent Resistor (LDR) to track the sun. Comparisons on fixed and tracking system were made and it was found that improvement of extraction of solar energy up to 24% over fixed one [6].

Efficiency of solar energy extraction of PV cell depends on primarily solar radiation and sun position. Also depend on the environmental parameters such as dust, hail, humidity, altitude and geometric location. For a given geometric location and altitude, the parameter which varies the extraction solar power with dust that deposited on the solar panel and hailstorm that may permanently damage or reduce the efficiency of solar panel. Vinay Guptha et.al reviewed the effect of dust on solar photovoltaic system and reduction techniques. From the reviews, there is no fixed dust mitigation technique and schedule of remove of dust and it was also suggested that future investigation was required to study bonding force between dust particle and solar panel with and without rainfall [7, 8].

II. OBJECTIVES AND CONCEPTUAL DESIGN

Regular solar panels cannot collect solar radiation effectively because the sun's position varies with time. If dust is not removed, it can reduce the efficiency of a solar PV module by shading the top surface of the panel. When the modules are not cleaned for 30 days, the energy output from a PV panel with dust will drop by as much as 50%. The main objective is to increase the absorption of solar radiation incident on the solar panel and to increase the overall efficiency of solar power.

The block diagram shown in fig. 1 represents the conceptual design of solar tracker. The lead acid battery supplies power to Arduino uno microcontroller which inputs current to L298N driver. The L298N driver is connected to two DC motors to control the polarity. The DC motor 1 drives the shaft which rotates the worm and worm wheel arrangement which in turn drives the horizontal shaft. The DC motor 2 turns the vertical shaft which opens the PV panel when light is detected by LDR sensor. The information from LDR sensor, rain sensor and position sensor is used by Arduino Uno to control the circuit. The PV panel is connected to load through charge controller. The horizontal shaft helps the PV panel to track sunlight in east – west directions. The position sensor helps the PV panel to take a position based on the direction in which the maximum intensity of sunlight is striking the panel. The panel closes during two instances: a) When enough light is not available b) When rain is detected by rain sensor.

The main objectives are

- To utilize maximum solar radiation using solar panel.
- To design a system that tracks sunlight
- To increase the efficiency and accuracy of the system by dust cleaning mechanism.

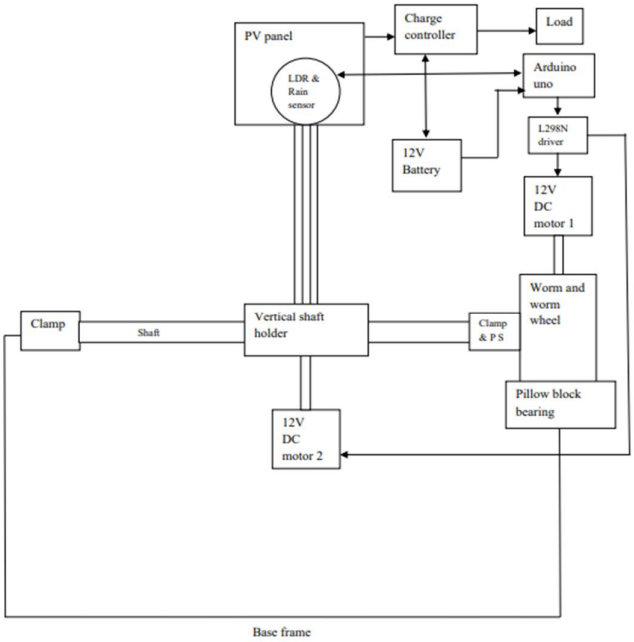


Figure 1. Conceptual Design of Solar tracker

III. FABRICATION AND TESTING

Different size combination of solar cell are chosen and mounted on petals and equivalent fixed solar panels are used compare solar tracking system. Dust cleaning arrangement was attached to each petal and dust removed when petal closes and opens in each cycle. To fabricate the solar tracker major components such as base frame, shaft, worm and worm wheel, petals and vertical shaft and hard-chrome shaft. Fig. 2 shows the major components and fabrication of solar tracker model. In order to control the solar tracker the following components are used.

a) PV panel
b) DC motor 12 V
c) LDR sensors
d) Rain sensor
e) Worm and worm wheel
f) Bearings
g) Battery
h) Charge controller
i) Arduino uno
j) L298N driver
k) Position sensor

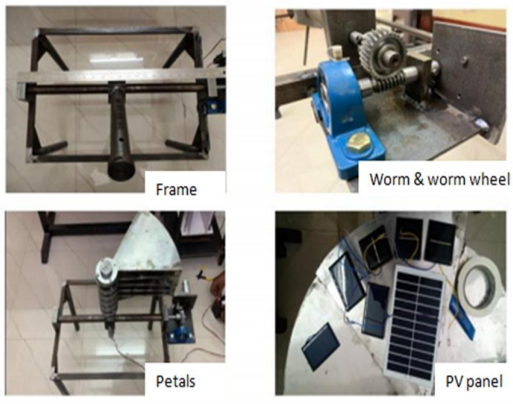
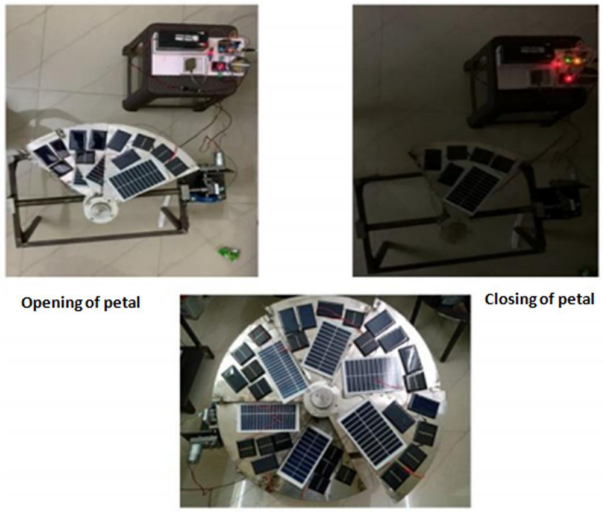


Figure 2. Fabrication of Solar tracker

Arduino is an electronics platform that uses simple hardware and software to make it easy to use. Arduino boards can read inputs signals such as light from a sensor, a finger on a button, or a set of instruction and convert them to outputs such as driving a motor or switching on an LED. Uno is an 8-bit ATmega-328P microcontroller-based microcontroller module. It comprises other components to sustenance the ATmega-328P microcontroller, for example a crystal oscillator, serial communication, voltage controller ect. The Arduino-Uno has a USB interface, six analogue input pins, and 14 optical input/output ports for connecting to other electronic circuits. Six pins of the 14 input/output ports can be used for PWM display. It enables developer to interact with and feel external electronic devices in the real world [9].
Fig. 3 shows the complete model of solar tracker with Arduino micro controller under opening and closing of petals when LDR senses the presence/ absence of light and rain sensor.



Figgure 3. Testing of Solar Tracker under light and dark conditions

IV. RESULT AND DISCUSSIONS

Results of voltage, current and power generated by solar panels are tabulated with solar tracker and without solar tracker shown in table 1. Fig. 4 shows the comparisons of power generation with and without solar tracking system. From the results it is observed that due to more direct radiations falling on the solar panel during solar tracking, the power generation increases. The efficiency of solar panel can be further enhanced by dust removal mechanism.

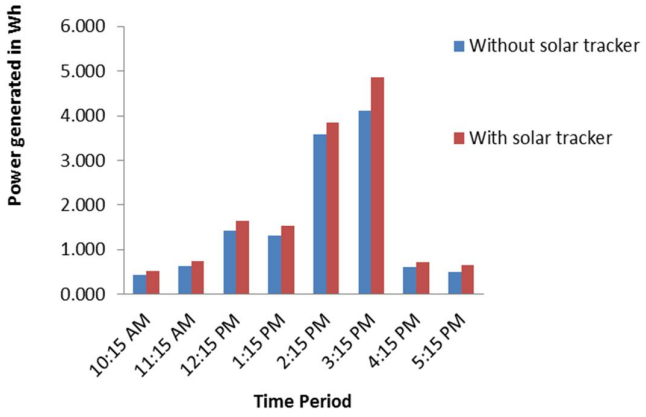


Figure 4. Comparison of Power generation of solar panel with and without solar tracker

TABLE I: POWER GENERATION OF SOLAR PANELS WITH AND WITHOUT TRACKER

Time	Without solar tracker			With solar tracker		
	V	mA	Power (W)	V	mA	Power (W)
10:15 am	84.900	11.000	0.443	88.400	12.100	0.513
11:15 am	96.600	14.100	0.636	99.600	15.700	0.739
12: 15 pm	111.500	26.600	1.430	117.700	28.760	1.636
01:15 pm	87.300	30.600	1.307	92.200	33.780	1.532
02:15 pm	115.900	64.700	3.579	118.600	67.600	3.849
03:15 pm	110.800	76.000	4.116	117.200	86.700	4.858
04:15 pm	96.700	13.200	0.605	102.300	14.780	0.723
05:15 pm	88.900	12.100	0.502	98.000	13.900	0.652
Total power		12.618 Wh		Total power		14.502 Wh

Total power generated without solar tracker=12.618 Wh

Total power generated with solar tracker =14.502 Wh

Percentage of increase in power generation due to solar tracker is 15%.

V. CONCLUSION

The tracking system is most efficient compared to fixed system. It is able to extract most of the solar energy which will be converted into electrical-energy. In terms of the power output of the solar panels with tracking and without tracking (fixed systems), it is manifest that the tracking system will have amplified power output. This is because the power generated by solar panels is dependent on the concentration of light. The more, light intensity, more the power that will be generated by the solar panel. The Software design(program) of this device is done in the way that the LDR-sensor, in harmony with the recognition of the sun rays and provide information to the DC Motor that in which direction the solar panel is going to rotate with help of potentiometer and L298 driver. By this, the solar panel is oriented in such a way that the maximum quantity of sun rays could be collected. Tracking system helps in the wider exposure of the panel to the sun with amplified power output. The major outputs are listed below.

1. The solar tracker with Arduino Uno controller was fabricated and tested successfully.
2. It is observed that the efficiency of absorption of solar radiation is increases upto15% with solar tracking. Efficiency of extraction of solar power is depending on so many parameters such as the geographic location, weather condition, pollution in the atmosphere, and seasons, like summer, winter and rainy, dusty environment.
3. Power generation is increases with solar tracking and by cleaning the dust on the surface of solar PV panel.
4. The suitable solar tracker model can easily implement on roof top of buildings.

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