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DUAL AXIS SOLAR TRACKING SYSTEM USING ARDUINO

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Abstract - *The world is now moving towards the renewable energy source due to various factors like pollution and cost of non-renewable energy sources. One of the major renewable energy sources is Sun. In this paper Arduino based Dual-axis solar tracking system proposed in order to get maximum solar energy. The Arduino is used to give command to rotate the solar panel. Solar trackers are used to improve the power gain from solar energy. Solar power is changes due to the seasonal variation and tilting of earth which changes the position of the sun in the sky. In this regard dual axis solar tracking is practically implemented and performance is compared with fixed mount and single axis solar tracking system. Finally, experimental result clearly evident that proposed method gives better efficiency compared to fixed mount and single axis solar tracking system.*

Key Words: Renewable Energy, Dual axis solar tracker, Arduino, LDR, Solar power.

1. INTRODUCTION

Solar energy is emerged as a possible source of renewable energy over the past two to three decades. This solar energy is converted into electrical energy by using solar panel according to the principle of photovoltaic effect. Out of various renewable energy sources solar energy is widely used. Because it is simple and it is easy to use in household too. Solar Trackers is a device used for the rotation of solar panel according to the sun's rays. To utilize this renewable solar energy solar trackers are employed [1]. For static solar panel, there is no movement in the panel. But the position of the sun changes during rising and setting (sun rises in the east and sets in the west). Due to this reason, single axis solar tracker is developed for rotation of solar panel in east and west direction. But due to the rotation and revolution of earth we cannot get equal amount of sunrays throughout the year. So that we adopted dual axis solar tracker to utilize the solar energy effectively and efficiently by rotating the panel in both horizontal and vertical direction. The main objective of dual axis solar tracker is to increase the efficiency of the solar panel by 30-45% when compared to the static and single axis solar tracker. The literature survey clearly shows the different methods of solar tracking for maximum utilization of solar power [1-15].

The single axis tracker is able to rotate only on horizontal (or) vertical. But this dual axis tracker is able to rotate on both horizontal and vertical movement. This dual axis solar tracker was implemented by using Arduino board [2]. Low cost of implementation by Arduino is the reason behind choosing Arduino in this project [3]. This was achieved even by using microcontroller [4].

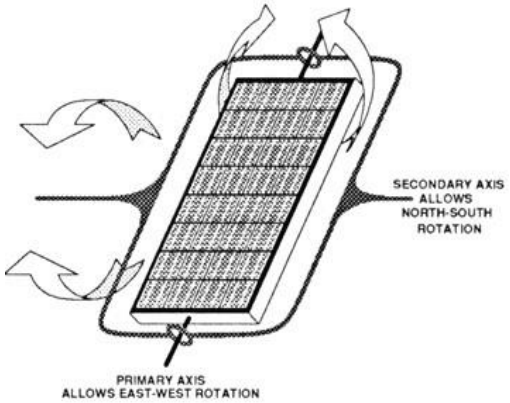

Figure.1 Mechanism of dual axis tracker

The above figure.1 shows the basic operating mechanism of dual axis solar tracker. It is basically an Azimuth-Altitude dual axis solar tracker [5]. Altitude refers to elevation of angle between a substance and the observer's location. It is basically between the angles of 0-90◦. Zenith distance can also be used instead of altitude. Then azimuth is usually analysed from north and increasing towards east [6]. This is mainly employed to get the maximum efficiency when compared to the static and single-axis solar tracking system [7]. To achieve this, we used Arduino UNO, LDRs, DC motor, LCD and solar panel. In [8] automatic solar tracking and two axis solar tracking is proposed in [9] for better solar tracking based on the position of sun.

The main contribution of proposed paper is given below:

•To trace more solar power in different location in different time period in a day to get maximum efficiency.

•To develop the Arduino based Dual axis solar tracker.

•To compare the efficiency of dual axis tracker with single axis tracker.

2. DUAL AXIS SOLAR TRACKER

The block diagram of our dual axis solar tracker system is shown in Figure.2. It consists of an Arduino board, LDR, LCD display, DC motor. An input command is given to the Arduino board. Four LDRs are connected to the light comparison unit [14]. This unit gives signal to the Arduino. The Arduino in turn command the motor driving circuit to rotate the solar panel in horizontal or vertical position.

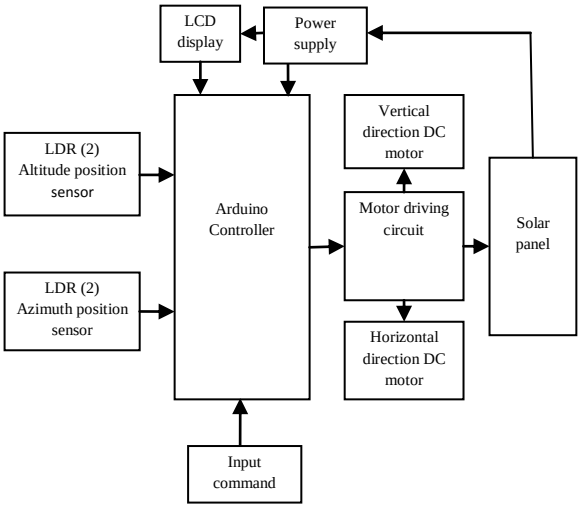

Figure.2. Block diagram of dual axis solar tracker

3. WORKING

In this system, four LDRs are fixed to sense the intensity of light (Two for Azimuth position sensor and another two for Altitude position sensor). The analog signal from the sensors is given to the in-built ADC (Analog to Digital Converter) and light comparison unit. This output is given as an input to the Arduino board along with the input command. The output of the Arduino is given to the motor driving circuit. Two DC motors are connected with the driving circuit, one for vertical and another one for horizontal movement. The motor rotates the solar panel perpendicular to the position of sun's rays. Then finally the output power is displayed in the LCD. In this project, LDR combination plays an important role. The combination of signals is fed to the Arduino and this bit pattern is shown in table 1.

Table.1 Desired Bit Pattern

LDR 1	LDR 2	LDR 3	LDR 4
1	1	0	0
0	1	1	0
0	0	1	1
1	0	0	1

When the motor gets the last bit pattern in the table 1, the motor will move the panel to its initial position and again follow these steps, when sun starts rising in the next day. Even a load is taken from the solar panel by connecting the panel with battery and inverter. The battery is used to store and give the DC supply to the inverter, which is taken from the solar panel. Then the output DC supply was given to the inverter which converts DC to AC. Then a load is connected along with it. This function is represented in the Figure.3 which is shown below.

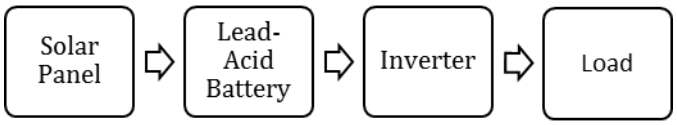

Figure.3 Block diagram of Output side of solar panel

The major components which are used in dual axis solar tracking system are:

1. Solar panel
2. Arduino board
3. LDRs
4. Motor driver
5. DC motor
6. Lead Acid battery
7. Inverter

3.1 Solar panel

The solar panel works based on the principle of photovoltaic effect which converts the solar energy into electrical energy [10]. There are various types of panels are available like monocrystalline, polycrystalline, amorphous, and hybrid. In this project we use 40W 12V amorphous solar panel is considered.

Figure.4. Amorphous solar panel

The Amorphous solar panel was shown in above Figure.4. The cost and silicon requirement of amorphous panel is low when compared with the other types of solar panel.

3.2 Arduino

In our project, we proposed Arduino based dual axis solar tracker [11]. Arduino board unit controls the movement of solar panel that rotates and traces the direction of sun [12]. Arduino board uses variety of microcontrollers and controllers. It is equipped with both analog and digital input/output. It has 14 digital input/output pins (of which six is used as PWM output), six analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack and a reset button is used. The input command was given to the Arduino using Integrated Development Environment platform. The Arduino Uno differs from all preceding boards because it does not use the FTDI USB-to-serial driver chip. Instead, it features the ATmega8U2 programmed as a USB-to-serial converter.

The Arduino board was shown in the Figure.5:

Figure.5. Arduino board

The specifications of Arduino board are listed in table.2 below:

Table.2 Arduino Uno specifications

Parameters of microcontroller	ATmega328
Operating Voltage	5V
Supply Voltage (recommended)	7-12V
Maximum supply Voltage (not recommended)	20V
Digital I/O Pins	14(of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40mA
DC Current for 3.3V Pin	50mA
Flash Memory	32KB of which 0.5KB used by boot loader
SRAM	2KB
EEPROM	1KB
Clock Speed	16MHz

3.3 Advantages

The advantages of tracking solar energy among various sources are:

•Solar energy is a pollution free form of source.
•There is no noise pollution as in wind energy.
•Once the solar power plant is fixed, maintenance cost is relatively low when compared to other existing sources.
•Solar energy can be used in very remote areas where extension of the electricity power grid is costly.

4. RESULT AND DISCUSSION

This section presents and discuss the performance of different tracking system and proposed system with respect to different time period in a day.

Table.3 Output power obtained in Fixed Mount, single-axis and Dual axis

Hours	**Power for Fixed Mount in W**	**Power for Single-Axis in W**	**Power for Dual-Axis in W**
07.00	0.09	0.35	0.68
08.00	0.25	0.47	0.87
09.00	0.75	1.02	1.55
10.00	0.98	1.23	1.78
11.00	1.58	2.24	2.86
12.00	2.5	3.1	3.15
13.00	2.22	2.54	2.98
14.00	1.88	2.11	2.44
15.00	1.58	1.86	2.3
16.00	1.56	1.7	2.01
17.00	0.78	0.98	1.56
18.00	0.44	0.65	0.78
Sum= 12 hrs.	Sum=14.61W	Sum=18.25W	Sum=22.96W
Solar Energy in W/hr. (Day Time)	1.2175 W/hr	1.5208 W/hr	1.9130 W/hr
All Day Solar Energy Output	**0.6087 W/hr**	**0.7604 W/hr**	**0.9566 W/hr**

The powers tracking of solar panel with different positions are tabulated above in table 3. It is clearly evident that the proposed dual axis tracker perfectly aligns with the sun

direction and tracks the sun movement in a more efficient way and has a tremendous performance improvement. The experimental results clearly show that dual axis tracker is superior to single axis tracker and fixed systems. Power Captured by dual axis solar tracker is high during the whole observation time period and it maximizes the conversion of solar irradiance into electrical energy output is shown in the table.3. As a result, it creates a solution for effective utilization of solar energy and thus helps in creating smart houses.

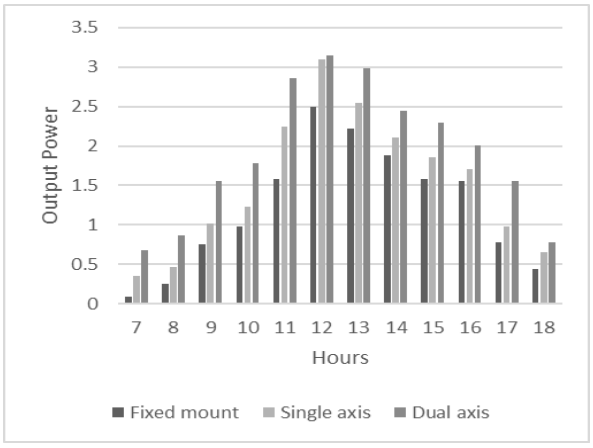

Figure.6 Bar Chart comparison for different tracking system

Bar chart comparison of solar power with different tracking methods is shown above figure.6. It is clearly showing that proposed method yields better output power compared to existing method.

5. CONCLUSION

The Arduino based dual axis solar tracking based solar panel is designed and successfully implemented to increase the efficiency of solar panel. The proposed dual axis solar tracker is more effective than the existing single axis solar tracker and fixed mount. The proposed solar tracker which automatically tracks the sun to grab maximum solar power with the help of Arduino board was effectively achieved. The implementation cost of Arduino board for tracking solar power is low and it is implementation is simple. Finally, experimental system clearly reveals that proposed system effectively tracks the sun in both good and bad weather conditions. During different time periods in a day compared with the existing system and efficiency of solar panel is effectively improved.

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