Dual Axis Solar Tracker

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***Abstract*— Solar energy is projected as one of the important energy in the future as a great renewable energy source. Solar cells vary its performance under temperature changes. Change in temperature affects the power. So it is very necessary to improve the efficiency of the solar PV cells. Efficiency can be increased either by changing PV material, concentrating solar rays or using solar tracking system. In this study we use for two axis solar tracking systems using electromechanical devices, in which a controller detects the Sun apparent position, and controls the position of the structure supporting the panels toward the sun. This work studies the solution of two axis solar tracking system based on use of photo sensor outputs. To accomplish this, it is used a low-power microcontroller, suitably programmed, to control two electric motors to ensure that the panels supporting structure is always oriented towards the sun.**

Keywords—Solar tracking system,sustainable and renewable energy, Power flow control, LCD.

I. INTRODUCTION

A large amount of energy is available within the core of sun. The energy that is received from sun in an hour is more than that is consumed by us in a working year. If humans are able to harvest even a fraction of the energy which we receive through solar radiation, then one can cater the need of our race for a long time. Efforts are continuously being made to harvest optimal amount of energy in order to store most of the energy which we are getting. The increasing interests in using renewable energies for detached houses come from solar thermal energy systems for local hot water and solar systems to the micro production of electricity. In order to maximize power output from the solar panels, one needs to keep the panels aligned with the sun. A two axes solar tracking system, according to several studies, increases the energy production by approximately 40%. The systems available on market are based on sensors that detect the Sun position.

This paper provides the description of a final year student project including the goal of the project and the design specifications. The feasibility criterion detailing the desired attributes of the design are included. Conclusion consists of the most optimal design, the recommendations, and the costs of the prototypes are also presented and discussed.

II. PROJECT DESCRIPTION

The system's main purpose is to efficiently harvest solar energy and convert the energy in to a useful form for everyday appliances and devices. The system responds to its environment in the shortest amount of time since it is fabricated as a real-time apparatus. It is able to make quick decisions to increase the efficiency and to ensure working safety; it always is aimed at a position to maximize the irradiance and limit the battery charge voltage to the indicated values. The system is fully automatic; however, the user could view critical real-time information about the system on an integrated LCD display unit

A. Tracking Mechanism

The dual-axis solar tracker follows the position of the sun in the sky together with following the sun's east-west movement. The dual-axis working is similar to single axis but it captures the solar energy more effectively by rotating in the horizontal and vertical axis. The tracker comprises of four LDR sensors, two stepper motors and PIC microcontroller. The set of sensors and one motor is used to tilt tracker in the sun's east - west direction and the other set of sensors and other motor which is fixed at the bottom of the tracker is used to move the tracker in the sun's north-south orientation.

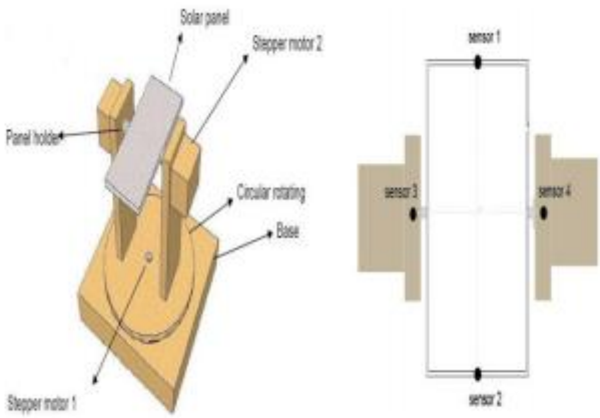


Figure 1

B. Methods Used For Tilting

To obtain tilting motion of the system with collector we have put to use a simple mechanism of rotation of semicircular bar on a fixed path. We have used 12mm square bar, bended into semicircle curve. A guide is provided for the motion of the bar on its perimeter as shown in fig (2) which we achieved manually. In which we connected dead weight at one side end and a wire on the other for adjusting the gradient. We then achieved this motion for tracing the sun.

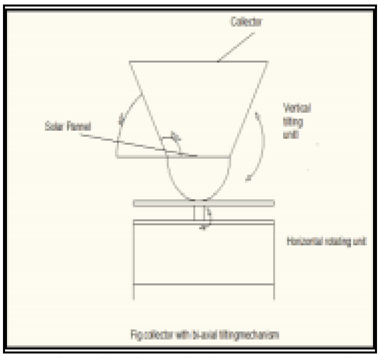


Figure 2. Biaxial Tilting Mechanism

C. Working and Specifications

The stepper motors help perform the function of sun tracking. The upper panel stepper motor traces the sun trajectory linearly and base stepper motor tracks the parabolic displacement of sun. These stepper motors and sensors are interfaced with the microcontroller which is controlling stepper motors on the basis of sensor's input. LDR sensors sense light input and sends signal to controller. Microcontroller compares signals received from LDR sensors and on the basis of stronger signal it decides rotation direction of the stepper motors. Dual Axis tracker control is explained in greater detail with the help of block diagram shown in figure 3. The block diagram shows that LDR sensors after sensing the light forward the signal to Microcontroller. Microcontroller is an intelligent device which takes actions on the basis of sensor input and activates the motor driver's circuit accordingly.

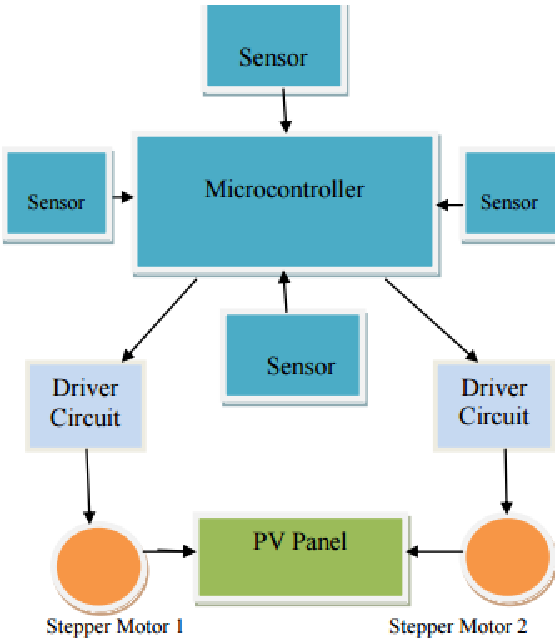


Figure 3: Block Diagram

The algorithm starts with collecting data from the 4 LDR sensors. Sensors output is analogue which is converted to digital signals by analogue to digital converter. Digitized signals are transferred to microcontroller. After collecting digitized signals, it decides about the movement and step angle of stepper motors. Controller algorithm is showing that microcontroller drives stepper motors only if sensor light sensing is unequal to each other and if sensor signals equate. It loops back to the start of algorithm. This process is repeated until light incident on sensor pairs is equal and PV panel is callibrated in a position for optimum power.

III. ELECTRONICS AND HARDWARE DESIGN

This section describes the entire electronics and hardware components that are part of the system and how they are interfaced

A. Inverter

The power inverter, commonly called inverter, is an electronic device or circuit that converts direct current (DC) to alternating current (AC). They have many applications in the electronics industry due to this ability. In this project, it is needed to convert the power coming from the solar battery into an AC form which is needed to power electrical devices. The inverter does not produce any power. The power it outputs is provided by current supplied by the battery which serves as a DC power source. An inverter can produce a square wave, a modified sine wave, a pulsed sine wave or a sine wave as an output depending on the circuit. In this case, a true sine wave is desirable since most electronic devices are programmed to function on. Inverters can be self-designed or bought as ready-to-use manufactured device.

The following equations and calculations were utilized to assist in coming up with the inverter design.

Turns ratio of transformer = (N2/N1)

$$V2 = V1*(N2/N1)$$

$$\Rightarrow (N2/N1) = V2/V1 \text{ ------- } (1)$$

$$\Rightarrow (N2/N1) = 120V/12V = 10$$

Also, for current, $I1 = I2*(N2/N1)$ -------- (2)

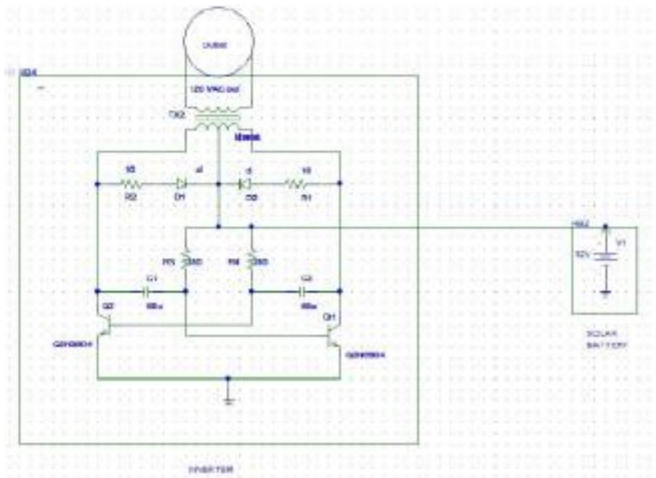


Figure 4: Inverter Circuit

B. Solar Panel

The high efficiency multi-crystal, Kyocera KD13GX-LPU PV module was used. It is 59.06" by 26.30" by 1.8". It has cell irradiance of 1000/m^2 at 25o C, an open circuit voltage of 22.1 V, and a short circuit current of 8.67 A.

Figure 5

C. Micro Controller

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. This device is manufactured with Atmel's high-density nonvolatile memory technology and is compatible with the standard 80C51 instruction set and pin layout. The on-chip Flash allows the program memory to be reprogrammed in-system or by means of a conventional nonvolatile memory pro-grammar. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a dynamic microcontroller which provides a flexible and cost-effective solution to many embedded control applications.

The AT89S52 provides the following features which include 256 bytes of RAM, 8K bytes of Flash, Watchdog timer, 32 I/O lines, two data pointers, on-chip oscillator, a clock circuitry, three 16-bit timer/counters, a six-vector two-level interrupt architecture and a full duplex serial port. Besides that, the AT89S52 is designed incorporating static logic for operation down to zero frequency and features two software selectable power saving modes. The Idle Mode terminates the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but pauses the oscillator, disabling all other chip functions until the next interrupt or hardware cycle.

D. Motor Controller

Since motors require more current then the microcontroller pin can typically generate, you need some type of a switch (Transistors, MOSFET, Relay etc.,) which can accept a small current, amplify it and generate a larger current, which further drives a motor. This entire process is done by what is known as a motor driver.

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which is capable of controlling a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC, Dual H-bridge Motor Driver integrated circuit (IC). The l293d can drive small and quiet big motors as well.

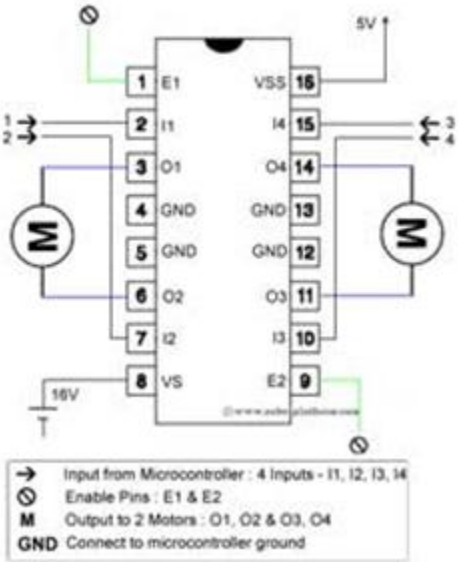


Figure 6

IV. EXPERIMENTAL RESULTS

Experiments results were observed by placing the designed system in open air. Table I, II & III show the output power for PV systems (stationary module, Single axis tracking and dual axis tracking). The output power data is collected during 8:00 A.M. to 6:00 P.M. In Table IV comparison of output power is shown in tabular form for three cases.

Table 1: Stationary module

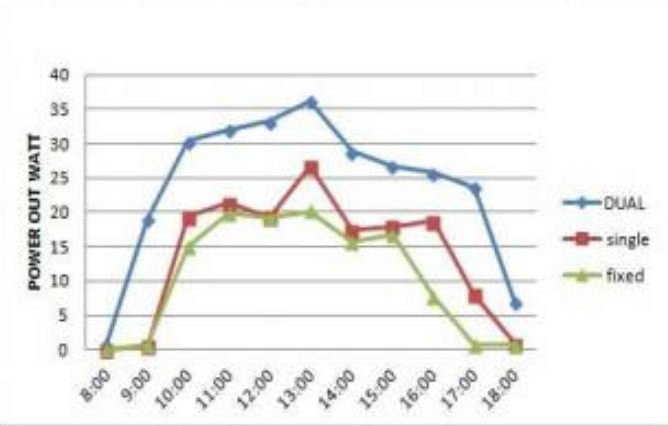
Time	Voltage(V)	Current(A)	Power(Watt)
0800	7.49	0.01	0.074
1000	15.04	1	15.04
1200	17.14	1.12	19.196
1300	17.70	1.14	20.178
1500	17.77	0.94	16.7038
1600	15.02	0.52	7.8104
1800	6.3	0.1	0.63

Table 2: Single Axis Rotation

Time	Voltage(V)	Current(A)	Power(Watt)
0800	4.57	0.001	0.0045
1000	14.7	1.32	19.404
1200	14.27	1.35	19.271
1300	16.47	1.71	27.1
1500	15.4	1.1	17.9
1600	15.9	1.19	18.8
1800	5.3	0.17	0.85

Table 3: Dual Axis Tracking

Time	Voltage(V)	Current(A)	Power(Watt)
0800	9.16	0.1	0.92
1000	21.12	1.44	30.41
1200	22.00	1.51	33.22
1300	22.05	1.64	28.87
1500	20.56	1.30	26.72
1600	20.45	1.26	25.76
1800	11.45	0.61	6.98



V. FUTURE SCOPE AND ADVANTAGES

- In future this Tilting mechanism with collector can be implemented on large solar plants and also can be operated automatically.
- We can make the work very easy with the help of electric tilting mechanism. We are working on the same to implementing automation for same mechanism with electric or mechanical actuators or components.
- This mechanism can be implemented on the Solar Cookers, Ovens, and Driers and on thermal solar heater.
- The main advantage of such systems is maximum amount of power generated due to the biaxial motion
- The total cost of tilting and tracking mechanism is less than the 25% that of cost of panel required to generate the same power.
- It produces 2.5 times more power than regular position of the solar panel.
- The construction of mechanism is very simple and handling of the system is very easy.

VI. CONCLUSION

The purpose of the proposed paper is to implement Bi-Axial system with collector effectively. The designed tracker for sun rays is found worked efficiently. The bi-axial tracking apparatus was found more effective than the single axis tilting mechanism. Due to use of collector on the panel the performance of the panel is doubled. The extracted power was observed to have increased significantly by using Bi-Axial tilting Mechanism. The same mechanism can be used for solar apparatus like oven, cooker, heaters, etc.

REFERENCES

[1] Bhavesh Pandey, Anita Agrawal “Automatic Sun Tracking System Using PSoC” International Journal of Innovative Research in Science, Engineering and Technology Vol. 1, Issue 1, November 2012.

[2] S. Abdallah and S. Nijmeh, “Two-Axis Sun Tracking with PLC Control,” in Energy Conversion and Management, vol. 45, 2004.1931-1939.

[3] Rani Molak , Vaishali Pawar, Omkar More, Atul Aradhye“Design Modification of Hybrid Solar Cooker” in International Journal of Advances in Management, Technology & Engineering Sciences Vol. III, issue 1(I), October 2013

[4] Jeya Ganesh N, Maniprakash.S, Chandrasekaran L., Srinivasan, S.M. “Design and Development of a Sun Tracking mechanism using the Direct SMA actuation”

[5] Kamala J , Alex Joseph “Solar Tracking for Maximum and Economic Energy Harvesting” Kamala J et.al / International Journal of Engineering and Technology (IJET)

[6] Kothari, D. P., and Nagrath, I. J. Modern Power System Analysis (3rd ed.). New Delhi: Tata McGraw-Hill Pub. Co., 2003.

[7] Solar Technologies | Photovoltaic Solar Panels | Thin Film Solar Panels | Solar Thermal. (n.d.).Solar Panels, Photovoltaic Systems, Solar Solutions for Home, Business & Utility-Scale — SunPower. Retrieved August 29, 2013, http://us.sunpowercorp.com/solar-resources/howsolar-works/solar-technologies/.

[8] Hossein Mousazadeh a, Alireza Keyhani a,*, Arzhang Javadi b, Hossein Mobli a, Karen Abrinia c, Ahmad Sharifi b,”A review of principle and sun-tracking methods for maximizing solar systems output”, a Department of Agricultural Machinery Engineering, University of Tehran, Iran

[9] N.A. Kelly, T.L. Gibson, Improved photovoltaic energy output for cloudy conditions with a solar tracking system, Solar Energy 83 (11) (2009) 2092-2102.

[10] G.C. Bakos, Design and construction of a two-axis Sun tracking system for parabolic trough collector (PTC) efficiency improvement, Renewable Energy 31 (2006) 2411-2421.

[11] J.C. Costa, Solar thermal facilities, Instituto Nacional de Engenharia, Tecnologia e Inovação – INETI (National Institute of Engineering, Technology and Innovation), 2007. (in Portuguese)