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Designing a Dual-Axis Solar Tracking System for increasing efficiency of a Solar Panel

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ABSTRACT: This paper shows the potential system benefits of simple tracking solar system. The main objective of this project is to present development of an automatic solar tracking system in which solar panels will keep aligned with the Sunlight in order to maximize in harvesting solar power and also to display the voltage generating from the solar panel. The system focuses on the controller design where the system is able to track the maximum intensity of Sunlight. When the intensity of Sunlight is decreasing, this system automatically changes its direction to get maximum intensity of Sunlight. LDR acts as a sensor is used to trace the coordinate of the Sunlight by detecting brightness level of the Sunlight. To control the appropriate position of the panel, a DC motor is used. The system is controlled by a microcontroller as a main processor. This project is designed for low power and residential usage applications. From the hardware testing, the system is able to track and follow the Sunlight intensity in order to get maximum solar power at the output. This project is designed with AT89S52 Microcontroller unit. Depending upon the light falls on LDR the data will be read by the Microcontroller and the direction of the motor will be changed. With this direction the Solar panel which is attached to the motor also rotates to gain the maximum sun rays. A solar tracking system is designed, implemented and experimentally tested. The design details and the experimental results are shown.

KEYWORDS: LDR, duel axis solar tracker, microcontroller, Keil compiler, efficiency.

I.INTRODUCTION

Most of the electricity in India comes from fossil fuels like coal, oil and natural gas. Today the demand of electricity in India is increasing and is already more than the production of electricity whereas the reserves of the fossil fuel are depleting every day. Sun throws so much energy over India, that if we can trap few minutes of solar energy falling over India we can provide India with electricity for whole year. Most parts of India get 7KWh/sq-meter of energy per day averaged over a year. The main aim of this project is to generate the maximum power from solar panel by continuously tracking the sun rays. The purpose of the project is to implement a system to continuously track the sun rays with the help of the solar panel and collect the maximum power from the sun by rotating the solar panel according to the sun rays direction. But the main drawback of the solar tracking system is that it is very poor efficient system. By using this project we can improve the efficiency of solar tracking system. In this system the solar panel will turn according to the sun rotation. The system focuses on the controller design where the system is able to track the maximum intensity of Sunlight. When the intensity of Sunlight is decreasing, this system automatically changes its direction to get maximum intensity of Sunlight. LDR light detector acts as a sensor is used to trace the coordinate of the Sunlight by detecting brightness level of Sunlight. A DC motor is used to rotate the appropriate position of the panel. The system is controlled by a microcontroller as a main processor. Whenever the radiation of the sun falls on the solar panel it grasps the radiation and stores in it and it will send the message to the controller about its power. Microcontroller will receive this information. From the hardware testing, the system is able to track and follow the Sunlight intensity in order to get maximum solar power at the output.

Solar tracking approaches can be implemented by using single-axis schemes, and Dual-axis structures for higher accuracy systems. In general, the single-axis tracker with one degree of freedom follows the Sun's movement from the east to west during a day while a dual-axis tracker also follows the elevation angle of the Sun. In recent years, there has been a growing Volume of research concerned with dual-axis solar tracking systems. However, in the existing research, most of them used two stepper motors to perform dual-axis solar tracking. With two tracking motors designs, two motors were mounted on perpendicular axes, and even aligned them in certain directions. In some cases, both motors could not move at the same time.

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The main objective for this project is to develop the sun tracking solar system model which is a device that follow the movement of the Sun regardless of motor speed. Besides that, it is to improve the overall electricity generation using single axis sun tracking system and also to provide the design for residential use. LDR or light dependent resistor has been chosen as the sensor because LDR is commonly used in sun tracking system. This is because LDR is sensitive to the light. The resistance of LDR will decreases with increasing incident light intensity. For the controller, AT89S52 had been chosen. This ATMEL programming will give the pulse to the driver to move the motor. For the driver, bi-directional DC motor control using relay has been used. The motor controller had been chosen because it can control the motor to rotate clockwise and counter-clockwise easily. DC geared motor also been chosen because it has a hold torque up to 24 kg.cm and low rpm. LM7805 is used to convert the input voltage from the source to 5 V output because integrated circuit only need 5 V to operate.

II. SCHEMATIC DIAGRAM OF THE PROJECT

The complete circuit consists of two parts. In sensor and comparator part shown in fig.1, we get the output from the LDR through a comparator LM324 by comparing with the reference voltage set and given to the Port 1 of AT89C51. Firstly four LDR are connected to the comparator. We are getting output of the LDR through 1KΩ resistance. The output from this LDR is given to the comparator LM324. Four LDR are used here and all of them connected in similar way. The output of LDR is given to the inverting terminal of the op-amp of the comparator. LM324 has four comparators in it. Reference voltage was set at 2.6 volt. As the light perpendicular to any LDR the corresponding output from the comparator is obtained. The LDR that is used here gives output voltage 2 volts when having perpendicular light on it. These outputs are given to the port 1 of microcontroller AT89C51.

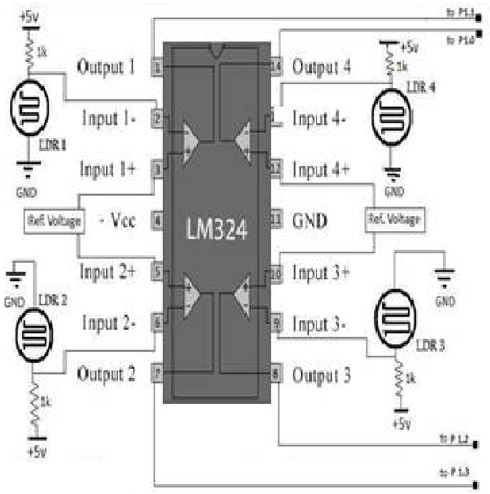

Fig. 1 The sensor and comparator circuit

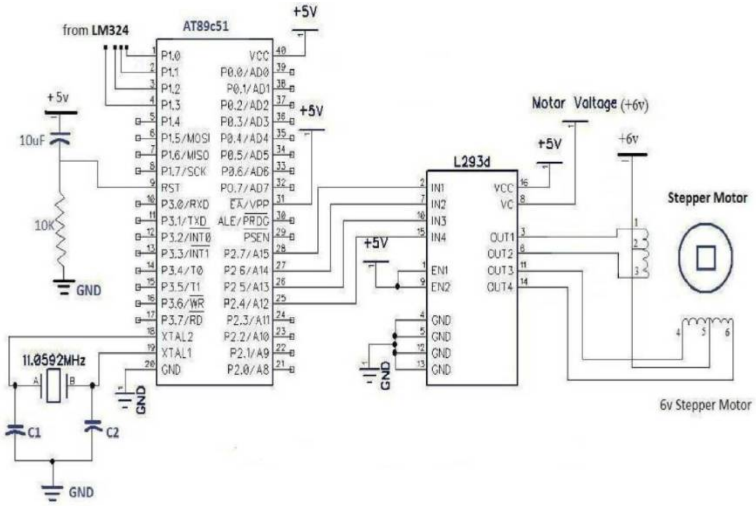

Fig. 2 Total circuit diagram

In the second part the interfacing circuitry of the Unipolar Stepper Motor is connected with microcontroller AT89C51 which is shown in Fig.2. Here we have used L293D as the motor driver. Using program it is compared the bit pattern and send signal to the motor driver to drive the stepper motor in specified direction. The circuit diagram is shown in Fig. 2.

III. TRACKING CONTROLLER SYSTEM AND MICROCONTROLLER PROGRAMMING

An automated solar tracker allows the panel to perform an approximate 3-dimensional (3-D) hemispheroidal rotation to track the sun's movement during the day in order to maximize in harvesting solar power. Light gathering is dependent on the angle of incidence of the light source providing power (i.e. the sun) to the solar cell's surface. Day sunlight will have an angle of incidence close to 90° in the morning and the evening. At such an angle, the light gathering ability of the cell is essentially zero, resulting in no output. As the day progresses to midday, the angle of incidence approaches 0°, causing a steady increase in power until at the point where the light incident on the panel is closer to perpendicular and maximum power is achieved. From this background, we see the need to maintain the

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maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible. By tilting the solar panel to continuously face the sun, this can be achieved. This process of sensing and following the position of the sun is known as Solar Tracking. Two LDR light detectors act as sensors to trace the coordinate of the Sunlight by detecting brightness level of Sunlight.

- When LDR1 has higher light intensity than LDR2 then the resistance of LDR1 is smaller than that of LDR2 then voltage at CH-1 is higher than that of CH-2 and the DC motor rotates the solar panel in the counter clockwise direction.
- When LDR2 has higher light intensity than LDR1 then the resistance of LDR1 is larger than that of LDR2 then voltage at CH-1 is smaller than that of CH-2 and the DC motor rotates the solar panel in the clockwise direction.
- The stable position is when the two LDRs having the same light intensity. Another two LDR also act as same principle.

The system is controlled by a microcontroller as the main processor. When the intensity of Sunlight is decreasing, this system automatically changes its direction to get maximum intensity of Sunlight and generate maximum power as output.

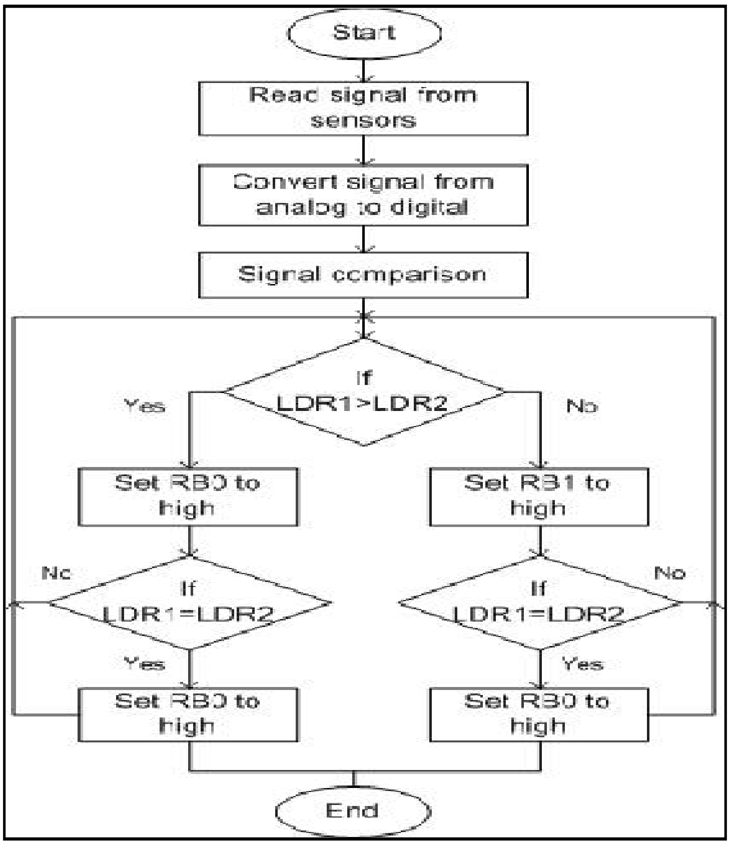

Fig. 3 Flowchart of the tracking principle.

```
#include <REGX51.H>
void main()
{
P3=0xff;
while(1)
{
if(P3==0x01)
{
P3=0x10;//00010000
}
else if(P3==0x02)
{
P3=0x20;//00100000
}
else if(P3==0x04)//00000100
{
P3=0x40;//01000000
}
else if(P3==0x08)//00001000
{
P3=0x80;//10000000
}
P3=0xff;
while(1) ;
}
}
```

Fig.4. Program in c language

Keil compiler is software used where the machine language code is written and compiled. After compilation, the machine source code is converted into hex code which is to be dumped into the microcontroller for further processing. Keil compiler also supports C language code.

1. Click on the Keil µ Vision4 Icon on Desktop
2. Click on the Project menu from the title bar
3. Then Click on New Project
4. Save the Project by typing suitable project name with no extension in our own folder sited in either C:\ or D:\
5. Then Click on save button above

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6. Select AT89S51
7. Then Click on “OK”
8. Then Click either YES or NO.
9. Now our project is ready to USE
10. Now double click on the Target1, we would get another option “Source group 1”
11. Click on the file option from menu bar and select “new”
12. Now start writing program in either in “C” or “ASM”
13. For a program written in Assembly, then save it with extension “. asm” and for “C” based program save it with extension “ .C”
14. Now right click on Source group 1 and click on “**Add files to Group Source**”
15. Now Press function key F7 to compile. Any error will appear if so happen.
16. If the file contains no error, then press Control+F5 simultaneously.
17. Then Click “OK”
18. Now click on the Peripherals from menu bar, and check required port
19. Drag the port a side and click in the program file. Now keep Pressing function key “F11” slowly and observe.

Steps to work with proload:

1. Install the Proload Software in the PC.
2. Now connect the Programmer kit to the PC (CPU) through serial cable.
3. Power up the programmer kit from the ac supply through adapter.
4. Now place the microcontroller in the GIF socket provided in the programmer kit.
5. Click on the proload icon in the PC. A window appears providing the information like Hardware model, com port, device type, Flash size etc. Click on browse option to select the hex file to be dumped into the microcontroller and then click on “Auto program” to program the microcontroller with that particular hex file.
6. The status of the microcontroller can be seen in the small status window in the bottom of the page.
7. After this process is completed, remove the microcontroller from the programmer kit and place it in your system board. Now the system board behaves according to the program written in the microcontroller which is shown in Fig. 4.

IV. FABRICATION AND INSTALLATION

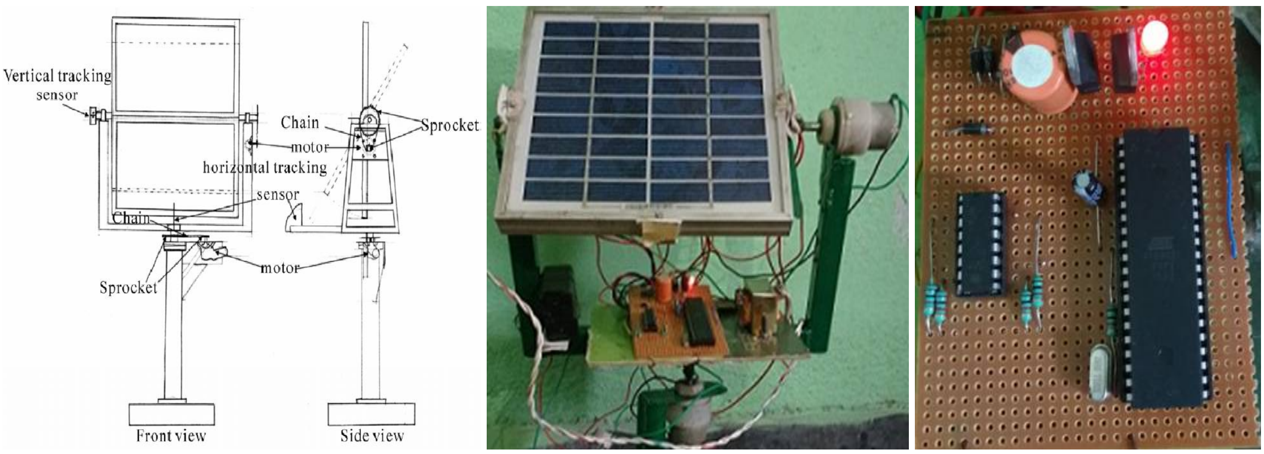

Fig.5 Finalised design of the structure

The miniature prototype tracker was constructed using materials like iron, Double-sided Tape and a few cutting tools. To enable dual-axis rotation, the panels were stuck onto a particle board base slightly larger in dimensions than the panels using double-sided tape. The LDRs were placed on the centres of all four sides of the board and also at the centre of the whole board. At the bottom of the base an aluminium rod was attached from the centre extending to any one of the sides of the base.

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V. RESULT AND CONCLUSION

Dual-axis tracking generates 40% more power from each panel. So we can achieve the same power output with fewer panels, frames and so on, which reduces a project's upfront costs and offsets to a great extent the additional cost for tracking hardware. On the other hand we can use the same number of panels as originally planned and generate 40% more power and higher revenues. This reduces the project's payback time and also increases the overall return on investment (ROI), depending on the financial specifics of the project.

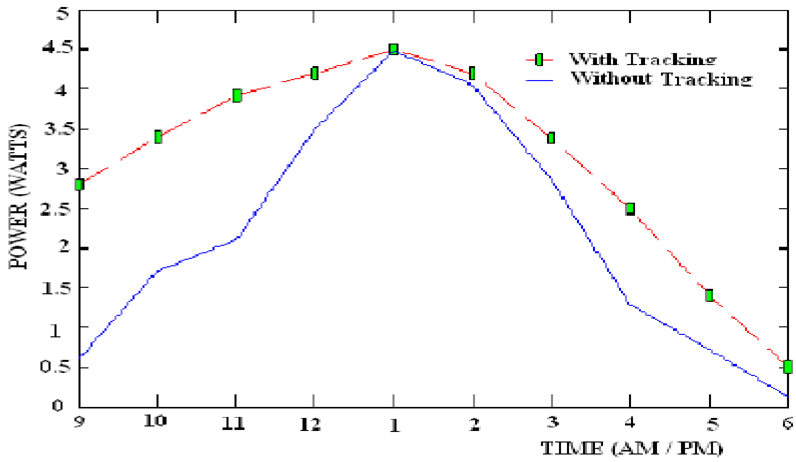

Fig. 6 Dual axis tracking can increase energy by about 40% of the fixed arrays

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 tracking is superior to single axis tracking and fixed module 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. The proposed system is cost effective also as a little modification in single axis tracker provided prominent power rise in the system. Through our experiments, we have found that dual axis tracking can increase energy by about 40% of the fixed arrays.

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