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Automatic Solar Tracking System

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ABSTRACT

The solar energy is a clean, freely and abundantly available alternative energy source in nature. Capturing solar energy from nature is an advantageous task for power generation. Conversion of sun energy into another form is a highly complex phenomenon. For this purpose, Photo-Voltaic (PV) panels are used which convert Sun energy to Direct Current (DC) electrical energy. Conventional fixed type PV panels extract maximum energy only during 12 noon to 2 PM which results in less efficiency. Therefore, building of an automatic solar tracking system is the need of an hour. PV panels have to have a perpendicular angle with the sun for maximum energy extraction which can be fulfilled by automatic tracking. This paper includes the design and development of Microcontroller based solar tracking system. This uses Light Dependent Resistors (LDRs) to sense the intensity of sunlight. The mechanism uses geared DC motors to rotate the PV panel. Liquid Crystal Display (LCD) is also used to display the output DC voltage, current and ambient temperature.

Keywords— **LDR, Microcontroller, DC motors, PV panel, LCD Display**

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I. INTRODUCTION

Solar energy is clean and renewable source of energy which is abundantly available in nature .Natural light is the major source of light for human beings but unfortunately till recent years it has been limited traditional modes of transmission such as through windows. Photo-Voltaic panels enhanced the use of natural light for various purposes. Today rooftop mounted solar panels are very common as they are used for solar water heating purpose. They are popularly called as fixed PV panels. They are inclined at a fix angle towards the Sun and the light falling upon the PV panels gets converted to the DC source of energy. This is the main feature of PV panels. Sun's position is not fixed in the sky throughout the day as it travels from east to west. So having PV panels fixed in nature, maximum amount of energy extraction would not be possible as the Sun will not remain perpendicular to the PV panels for full day except 12 noon to 2:00 PM (almost perpendicular).

To overcome this issue Automatic Solar Tracking System has been designed for maximum energy conversion from photon energy to electron energy. This system keeps solar PV panels perpendicular to the position of the Sun throughout the day resulting in more efficiency than fixed PV panels.

Section II of this paper is literature review, which reveals the study of existing work in the solar tracking field and also gives the existing designs of the same. Literature review also reveals different tracking mechanisms which can be used to continuously track the sun. Section III, highlights the design and development part of the Automatic Solar Tracking System. This chapter also reveals the various types of parts and components used in tracking system. Section IV discusses about simulation results of the system. In Section V, the software development is stated. Section VI explains experimental results and section VII concludes the Automatic solar tracking system and future scope of this work.

II. LITERATURE REVIEW

This literature review reveals the detailed work that has been carried out till date on the topic of Solar Tracking. Authors N.Othman, M.I.A. Manan *et al.* have presented the performance analysis of a dual axis solar tracking system using Arduino. In project development, five Light Dependent Resistors have been used to track the sun and

two servo motors have been employed to move the solar panel to maximum light source indicated by LDRs. The software part consists of a code written in C programming language and implemented by the Arduino UNO controller [1]. Md. Tanvir Arafat Khan, S.M. Shahrear Tanzil (2010) have designed and constructed a microcontroller based solar tracking system using LDRs to sense the intensity of sunlight and stepper motors to move the Photo-Voltaic (PV) panels in accordance with the sun [2]. Fabian Pineda, and Carlos Andres Arredondo (2011) have designed and implemented a two-axis sun module positioning by sensing the maximum brightness point in the sky. A geodesic dome based sensor has been built for the bright point tracking [3].
Authors Salabila Ahmad et al. have designed and constructed an open loop two axes sun tracking system with an angle controller. The hardware is selected such as it will maximize the power collected and minimize the power consumed as the efficiency parameter lies in between these two power parameters [4]. Solar tracking also helps in transmitting sunlight to dark area like basement. Authors Jifeng Song *et al*. have implemented the high precision tracking system based on a hybrid strategy for concentrated sunlight transmission via fibres [5]. Authors A.chaib *et al* (2013) have presented the heliostat orientation system based on PLC robot manipulator. It is presented that by mounting certain no. of heliostats and facing them towards central power tower water can be heated and turbines can be driven for energy conversion purpose. By applying MATLAB program for determining the sun's position for heliostat orientation and by using PLC robot manipulator it is presented that maximum amount of energy gets converted from solar to electricity. Concentrated Solar Power (CSP) is used in this experiment [6]. Authors Tao Yu and Guo Wencheng (2010) have introduced automatic sun-tracking control system based on Concentrated Photo Voltaic (CPV) generation. CPV generation works effectively when light panels trace the sun accurately. Stepper tracking control technology is used. This control relies on control circuit with ARM and camera which can provide powerful computational capability [7].

III. DESIGN OF TRACKING SYSTEM

In this study, a microcontroller (AT89C52) based Automatic Solar Tracking System is implemented. 4 LDRs are used to sense the intensity of the sunlight. LDR has the property of reducing its resistance as the light falling on it increases. Keeping this principle in mind a microcontroller program is written for tracking purpose. LDRs are connected to Analog to Digital Converter (ADC) because the Microcontroller understands the digital language and the output of LDR is an analog quantity. Three geared DC motors are used to move the solar panels. Out of them two are of 30 Revolutions per Minute (RPM) speed and one is of 10 RPM speed. A temperature sensor LM 35 is also used to keep a track PV panel output performance with change in temperature. A wireless protocol ZigBee (XBee) is also implemented to transfer the data from the actual place of hardware mounted (plant) to personal computer (PC/ supervising area). Zigbee (XBee) has an advantage of low power consumption and also has range of 10 to 100 meters.

Based on the literature review and current scenario of solar tracking, it was decided to build an Automatic Solar Tracking System as shown in Figure1. In this system, 4 LDRs and one temperature sensor are connected to ADC. Four LDRs are mounted on PV panel. In figure 1, the numbers 1, 2, 3, 4 are the four LDRs. The design and description of the system is such that the PV panel moves towards the direction of LDR which has a lowest resistance compared to the other three. Power supply is given to ADC, Microcontroller and DC motors.
Three DC motors are connected to the microcontroller and then to the PV panel. XBee transmitter receives signals from microcontroller and transmits those signals to the XBee receiver side at the PC end. These signals are each LDR's resistance value, PV panel
Output voltage, current and ambient temperature. The transmitted signals by XBee will be received by XBee receiver module and will be displayed on and stored in PC. A single 16*2 Liquid Crystal Display is also used to display the above mentioned parameters.

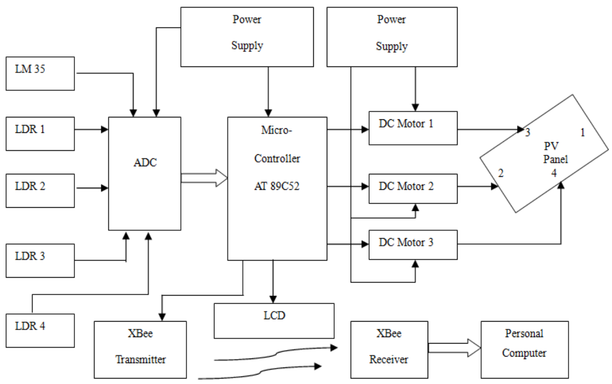

Figure 1: Block diagram of the implemented system

IV. SIMULATION RESULTS

Simulation of the Automatic Solar Tracking System is performed using Proteus software. Simulation process is carried out to judge whether the actual system will perform as per our expectations or not. Simulation process shows the actual connection diagram of each and every circuit diagram. It's an actual circuit diagram implemented in Proteus software.
Figure 2 shows the simulation diagram of the actual system

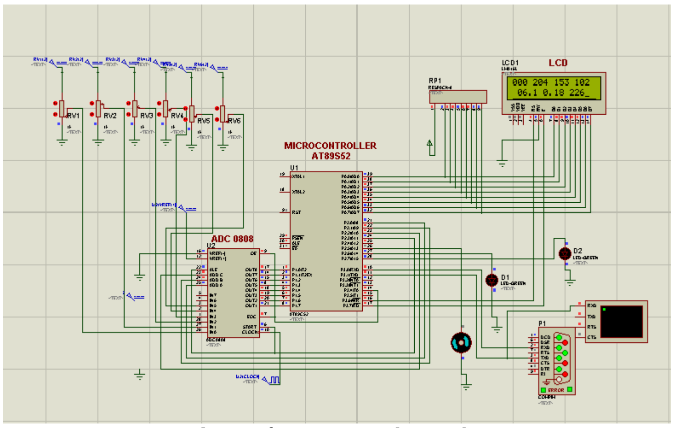

Figure 2: Simulation of Automatic Solar Tracking System.

V. SOFTWARE DEVELOPMENT

The software program to control the movement of the PV panel is written using Keil compiler and downloaded in microcontroller using software called Flash magic. The below shown flowchart discusses about the program flow of the actual system. The flowchart is shown in figure3. Flowchart is a symbolically described algorithm which explains the actual flow of the developed code. The program starts with the port initializing part and the serial communication initialization. Initialization process is required to carry out because microcontroller has to understand that at which port which component is connected.

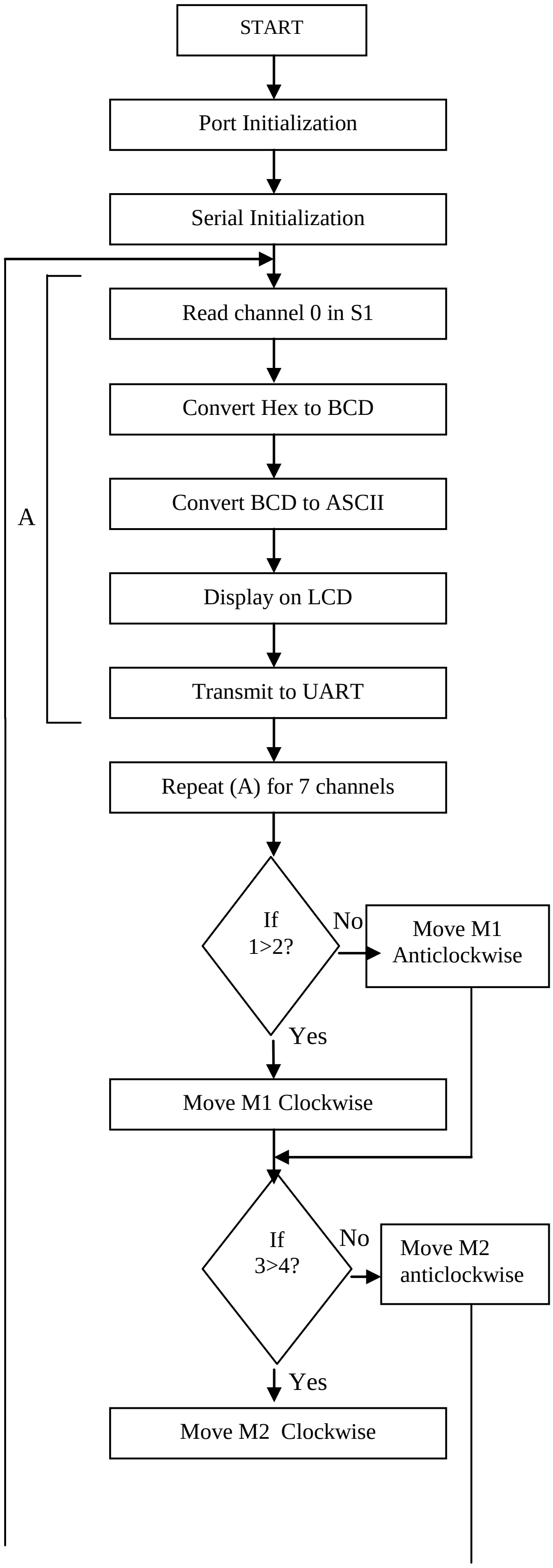

Figure 3: Software flowchart of automatic solar tracking system

In this microcontroller, 7 channels are used to detect 4 LDRs, PV panel output voltage, output current and ambient temperature which is sensed using LM 35. The data from channel 0 is read in a variable called S1. Then, this HEX data is converted to Binary Coded Decimal (BCD) to make microcontroller able to calculate and display that data. Further, the data is converted to American Standard Code for Information Interchange (ASCII) code to display it on LCD. The data gets displayed on LCD then. This procedure is repeated for all the 7 channels to sense all the parameters. 1 and 2 are LDRs as shown in figure 1. If LDR 1 detects light intensity more than 2(lower resistance than LDR 2) then the motor M1 will rotate clockwise else anticlockwise. Same is the case for LDRs 3 and 4. If LDR 3 detects light intensity (lower resistance than LDR 4) more than LDR 4 then motor M2 will rotate clockwise else anticlockwise. Hence, as shown in figure 3 the system will continuously be running

V.EXPERIMENTAL RESULTS

The experimental results of an Automatic Solar Tracking system on a particular partly clouded day are as shown in Table I. It can be seen from the table that although the maximum PV panel output is between 12 noon to 3 PM, the output is also in a good range for the rest of the day.

TABLE I: EXPERIMENTAL RESULTS OF AUTOMATIC SOLAR TRACKING SYSTEM

Sr. No.	Time	Output Voltage(V)	Output Current(A)	Output Power (V*I)	Temperature
1	7:00 AM	6.5V	0.25	1.625	28
2	8:00 AM	6.5V	0.30	1.95	29
3	9:00 AM	6.8V	0.32	2.17	29
4	10:00 AM	7.0V	0.40	2.8	31
5	11:00 AM	7.1V	0.48	3.40	33
6	12noon	11.4V	0.55	6.25	35
7	1:00 PM	11.5V	0.59	6.78	36
8	2:00 PM	11.7V	0.65	7.60	36
9	3:00 PM	11.2V	0.61	6.83	36
10	4:PM	10.4V	0.52	5.408	34
11	5:00 PM	8.3V	0.40	3.32	32
12	6:00 PM	6.5V	0.22	1.43	29

It can be seen from the table and the experimental results that as the temperature increases from morning to noon and then from noon to evening, the solar panel output changes accordingly. From 7 AM to 3PM the PV panel output gradually increases and from 3 PM to 7PM the output gradually decreases.

VI.CONCLUSION

A 89C52 microcontroller based Automatic Solar Tracking System has been implemented using geared DC motors and LCD. From Experimental results it can be concluded that the solar tracking system is more helpful in all senses than the fixed panel system.

In future, by connecting the solar panels in an array more energy can be extracted. Using aluminum type of material for the assembly set up the weight upon the motors can be reduced as compared to the iron assembly implemented in this project and hence the power consumption will also be less.

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