

Review On Automatic Solar Radiation Tracking System

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Abstract— Fossil fuels are a relatively short-term energy source and thus, there is a need for an alternative energy resource. The use of solar energy as an alternative source is becoming more wide spread. Implementing solar modules to convert solar energy into electricity is a common aspect, but the solar energy is not fully utilised. To make solar energy more useful, the efficiency of solar array systems must be maximized. A feasible approach to maximize the efficiency of solar array systems is Solar Radiation tracking.

Automatic Solar Radiation Tracker is a system that controls the movement of a solar array so that it is constantly aligned towards the direction of the sun. Various technologies are being used worldwide for the accomplishment of such systems. This paper reviews some of these technologies.

Index Terms— Solar tracker, Arduino, microcontroller AT89C51, PIC16F877A.

I. INTRODUCTION

The position of the sun in the sky varies in accordance with the time of day as the sun moves across the sky. Any solar powered equipment works best when it is pointed at or near the sun. So, it is obvious that an equipment which is powered by a stationary solar panel provides a less efficient output. Recent developments in solar energy focus on maximizing system efficiency. Several methods of solar tracking systems have been studied to keep the solar panel aligned to the sunlight. An ideal tracker would allow the solar panel to point accurately towards the sun.

There are two broad types of solar trackers:

Single axis

The single axis trackers can either have a horizontal or a vertical axis. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun does not get very high, but summer days can be very long.

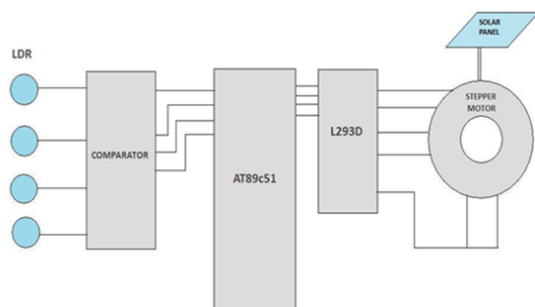
Dual axis

The dual axis trackers have both a horizontal and a vertical axis and thus they have a wide range of tracking, which makes them usable in corner of the world. Dual axis tracking is extremely important in solar tower applications.

II. LITERATURE REVIEW

This literature studies the various technologies that are used worldwide in the automatic solar radiation tracker systems.

Using AT89C51 Microcontroller, LDR and Stepper Motor



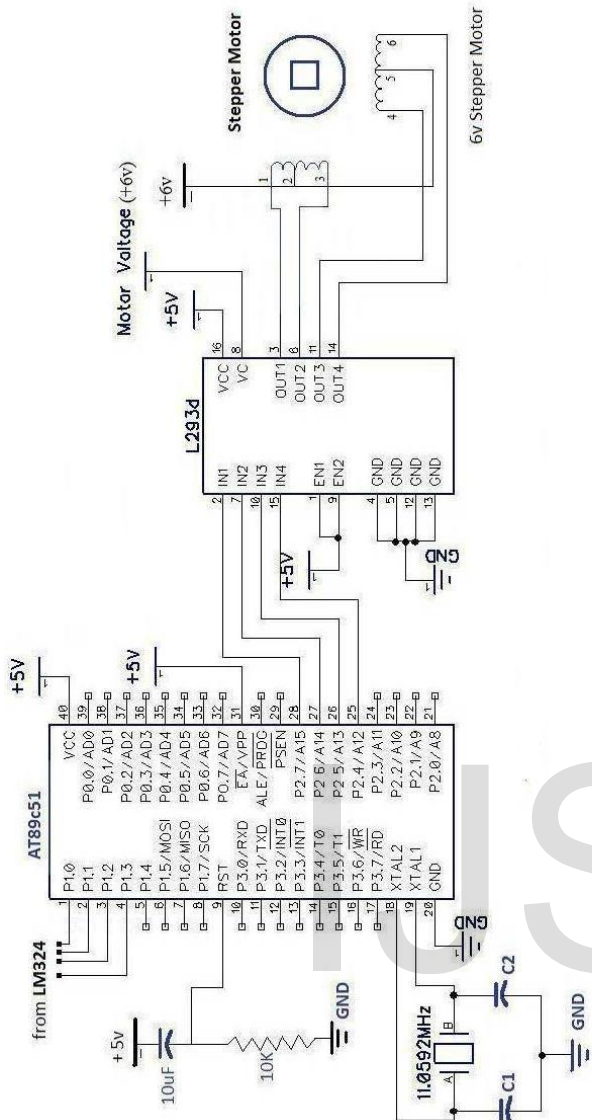
In this setup, the LDRs are placed on the surface of a large curvature. A provision is made such that any immediate two LDRs remain active at a time. The stepper motor follows the bit pattern of the LDRs, and thus, the solar panel connected on the shaft of the stepper always faces the sun normally. The LDR combination plays a crucial role. Basically, these signal patterns are fed to the microcontroller 8051 which in turn directs the motor associated to it. The required bit pattern is shown in the following table:

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 stepper motor gets the last bit sequence of the table, it moves to its initial position and again follows these steps, as the sun traverse from the beginning in next day.

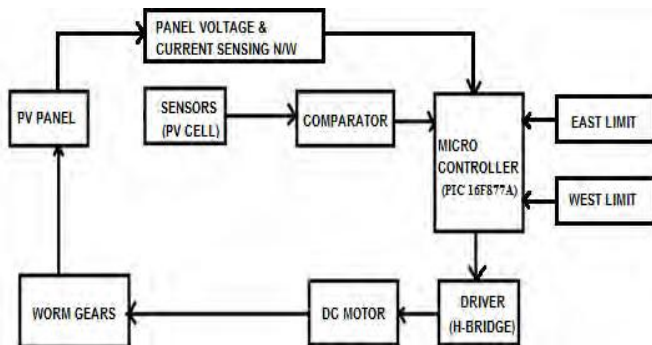
The outputs of the LDRs are given to the inverting terminals of comparator LM324 through a resistor, whose other input is a reference voltage. The LM324 has four comparators and so, all of the LDRs are connected to them. The output of LM324 is given to the Port 1 of 89C51. The Port 1 gets the input from the output of the comparator in particular bit pattern. Using a program it is compared with the desired bit pattern and a signal is sent to the motor driver to rotate the stepper motor in the specified direction. The motor driver used is an L293D, which is a quadruple high-current half-H. It is designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors etc. There are three ways to drive unipolar stepper motors, namely, one phase on full step, two phases on full step, or half step, out of which two phase full step mode is used in this setup in which successive pairs of adjacent coils are energized in turn.

The complete circuit diagram of the setup is shown in the following figure:



In this setup, difficulties are faced while placing the LDRs. If they are not placed properly, there is a possibility that more than one LDRs get activated at the same time, which is not desirable.

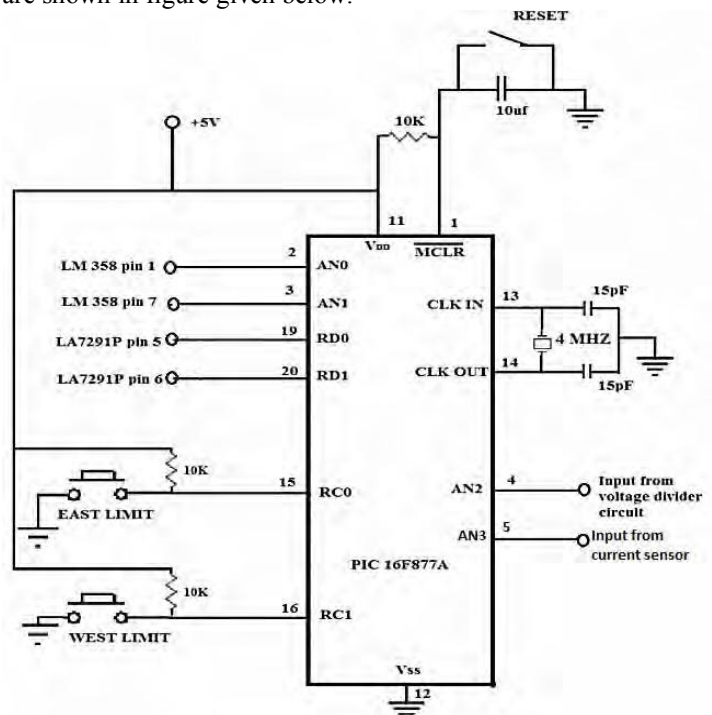
Using Microcontroller PIC16F877A and DC Motor



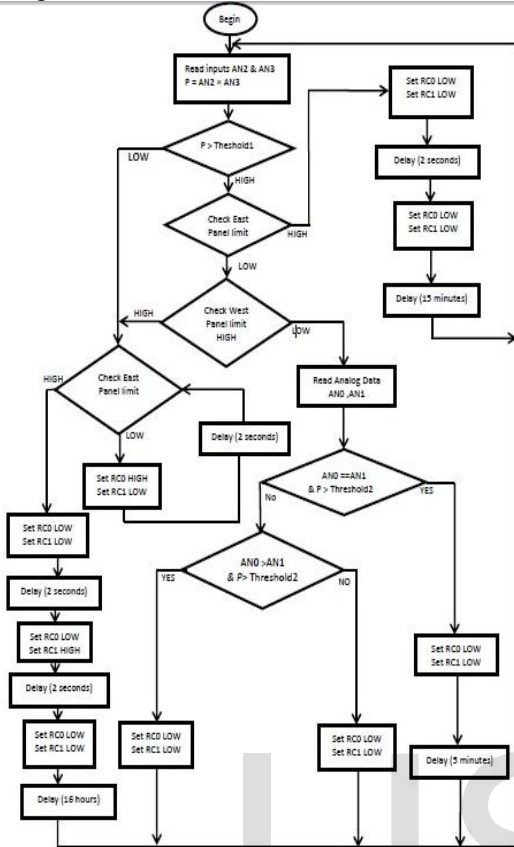
In this setup, the output of PV panel i.e. solar panel is compared and given to PIC microcontroller PIC16F877A for facilitating the tracking operation. The power derived from the

solar panel is determined by voltage, current sensor outputs, which is used to initiate the tracking algorithm. During rainy / overcast days, the output power is very low and the tracker is not activated to save power consumption of electronic circuits. Initially, the PV panel is tilted in the east direction and touches the east limit switch to initiate tracking. At the end of the day, it is tilted towards west direction and touches west limit switch. After the sunset, the output power reduces and the panel is brought back to the east side to initiate tracking for next day.

The microcontroller PIC16F877A performs the necessary operations in accordance with the power received from the solar panel. For this, two threshold levels are used. The first threshold is used to activate tracking, which indicates that there is a sufficient amount of solar energy available. The second threshold is used to switch off the peripherals if the significant solar power is not available for a long period of time, for example, a cloudy / rainy day. The solar panel is tilted towards east for facilitating tracking on the next day. Analog inputs are accepted by the PIC 16F877A and are converted into 10 bit digital data. The first limit is decided to be 400 to enable tracking and the second limit is set to 150. When solar power is greater than the first threshold limit, the tracker is activated. The device compares the intensity of light falling on the two sensors and aligns itself perpendicular to the radiation. Photovoltaic cells are used in this single-axis tracking system to decide the position of the solar panel. The cells are configured as east and west plane sensors for moving the single axis motion of the panel. The sensors are connected to the centre shaft of the panel. These sensors are placed in the form of triangle to as to make themselves sensitive to ambient light. Solar power less than second limit will switch off the peripherals and solar panel will tilt towards east direction. The controller implementation using PIC16F877A with peripherals are shown in figure given below:



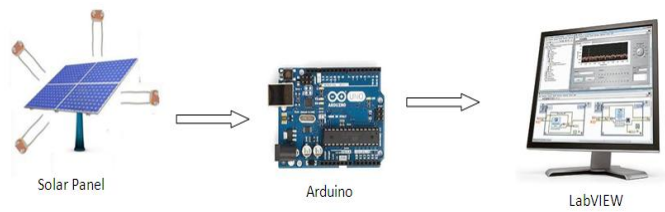
The following figure shows the flowchart of the control algorithm:



This tracking setup uses a 12V, 10N-m DC gear box motor. The motor speed which is 60rpm is reduced to 0.5rpm (3 degree) for efficient tracking. Other mechanical parts include a supporting frame, ball bearings at the two end of the shaft in which a 100W solar panel is fixed. The hardware of the system is designed with maximum friction free motion parts enabling increased overall efficiency than the existing systems. The PIC16F877A has an in-built ADC due to which the need for an external ADC is eliminated. This makes the electronic circuitry simple.

Using Arduino with LabVIEW

In this system, Arduino Uno is used as controller to track the sun and attain maximum efficiency and LabVIEW for real time monitoring. Arduino is a single-board microcontroller, which is used to make the application of interactive objects or environments more accessible. It is an open source physical computing platform and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. LabVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. The software is perhaps the most important component of the system.



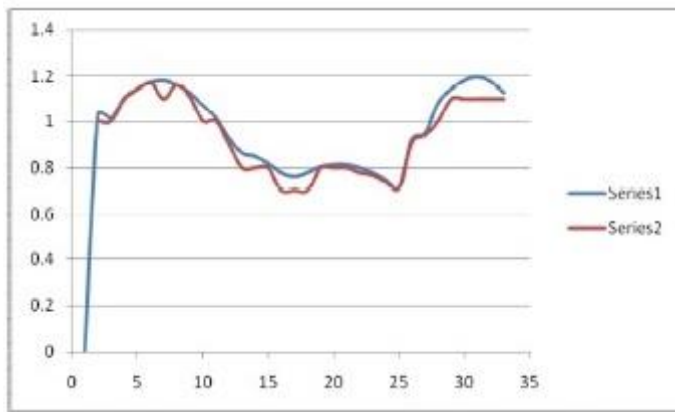
The LabVIEW Interface for Arduino (LIFA) allows users to control sensors and acquire data through an Arduino microcontroller using the graphical programming environment LabVIEW. Arduino microcontroller acts as an I/O engine that interfaces with LabVIEW VIs through a serial connection. This helps to move information from Arduino pins to LabVIEW without adjusting the communication, synchronization.

The vital component in the hardware of this setup is the Light Dependant Resistor (LDR). LDRs are basically light-controlled resistors and so they are suitable in applications where light/dark detection needed. Four LDRs are connected to the analog pins AO to A4 of the Arduino that act as the input for the system. The Arduino has an in-built Analog-to-Digital Converter which converts the analog value of LDR outputs and converts them into their digital equivalent value. The entire setup is, thus, divided into three parts, i.e. input, controller and output where inputs are from analog value of LDR, Arduino as the controller and the DC motor will be the output. LDR1 and LDR2, LDR3 and LDR4 are taken as pair. If one of the LDRs in a pair gets greater light intensity than the other, then a difference will occur on node voltages which is sent to the respective Arduino channel to take necessary action. The DC motor will move the solar panel to the position of the high intensity LDR that was in the programming.

Algorithm had been constructed using LabVIEW programming. The algorithm of the program is as follows:

- Step 1. Read all analog voltages from analog channels
- Step 2. When all voltages are equal, the motor will be in stop position.
- Step 3. When $LDR1 > LDR2$, the top motor will rotate clockwise.
- Step 4. When $LDR1 < LDR2$, then the top motor will rotate anticlockwise.
- Step 5. When $LDR3 > LDR4$, the down motor will rotate clockwise.
- Step 6. When $LDR3 < LDR4$, the down motor will rotate anticlockwise.

This setup, however, does not provide maximum efficiency. There is still a difference between the voltage values of the output of a moving solar panel and that of a stationary panel. This is shown in the following graph for a period of interval obtained from the experiment.



III. CONCLUSION

In this paper, we have reviewed three of the technologies used in Automatic Solar Radiation Tracker systems, namely, using AT89C51 Microcontroller, LDR and Stepper Motor, using Microcontroller PIC16F877A and DC Motor and using Arduino with LabVIEW. From the study of these technologies, it has been observed that by using Arduino based solar tracker system, the efficiency of radiation tracking system improves. The use of stepper motor as the tracking device not only facilitates rotation of the solar panel from east to west and back to east in a cyclic manner but it also tracks the angular movement accurately. This is a unique and flexible quality for which the tracker could easily be used in conjunction with solar panel to derive efficient energy. If we use AT89C51 microcontroller, the development time increases (especially if it doesn't work right the first time). The complexity of the circuit board increases on other hand. If we use PIC16F877A, the length of the program will be big as need to use RISC (35 instruction), also program memory is not accessible and only one accumulator is present.

IV. REFERENCES

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