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Design of a Solar Tracking System

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Abstract

The transformation efficiency of solar energy into electrical energy depends upon the tilt angle of the solar panel. So the fixed-type solar panel cannot utilize the optimal solar energy, the transformation efficiency of solar energy is limited. Many different light source sensors, light intensity sensors, intelligent vision techniques, and CCD equipments were applied to compute the absorption time of the sun radiation over the whole day for measuring the volume of solar energy. In this paper, the main goal is to design and implement a solar tracking system so that the solar cells always face the sun over the whole day time. Using LDRs as sensing devices and making the motor move in the direction of more dominating voltage signal outputted by the LDR. Therefore rotating in the direction of maximum sunlight it will increase the efficiency to capture maximum solar power from the sun.

Keywords: - Solar Tracking, LDR, PCB, Non-inverting op-amp

1. INTRODUCTION

The biggest concern of conventional energy sources is the pollutants that are released into the atmosphere. These growing concerns have lead to an alternative energy sources for conventional energy sources which are more efficient and pollution free. The most common method of electrical power generation uses fossil fuels such as coal, oil etc. However, the burning of fossil fuels releases CO2 gas which has been directly associated with global warming. Photovoltaic represent one of the few energy generation options that do not create pollutants or hazardous wastes [1]. Sun's rays are used as a renewable energy. Therefore devices that make use of such renewable resources are becoming increasingly popular. A solar tracker is a generic term used to describe devices that orient various payloads toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices. Making the maximum output from a solar system is desirable to increase its efficiency. For such a condition, the panels must be aligned with the sun's orientation and this can be obtained by using a solar tracking system. Instead of a stationary array, it's more efficient to rotate it by a tracking system. In our work we have developed a tracking device that will locate the direction of the sun's position to maximize the efficiency. We have selected the dynamic method as our project making it more flexible for us to move the tracker sensing the light rays.

2. DESIGN METHODOLOGY

In this work we used 3 main circuits for locating the orientation of the sun. As the light radiation falls on the sensor, the sensor circuit becomes active. After sensing the light, the motor driver circuit will operate depending on the movement of the sun from east to the west. At the end of the day, when the sun completely sets, a switching circuit will be activated which will trip the circuit and return the board to its original orientation.

A. Sensor Circuit

Figure1 shows the sensor circuit. 2 non-inverting op-amps integrated in a circuit (HA 17358) play the main role here. A 12 Volts DC battery source has been used to bias the IC and supply power to the circuit. Zener diode is also used here to keep the voltage at the negative end of the op-amp (pin 2 and 6) constant at 5.1 volts.

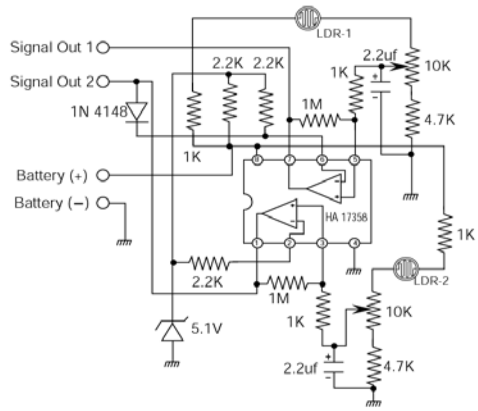

Fig 1: Sensor Circuit

When light falls on LDR2, the accumulated voltage passes through variable resistor and finally to the positive end of the op-amp (pin3). The output of this op-amp goes to signal out 2 which are connected to the motor driver circuit as input. Another part of this output is connected to the negative end of the op-amp (pin 6) through a diode (1N4148), where the output of zener diode gets accumulated together. The LDR1 is connected to the positive end of the op-amp (pin 5) through a variable resistor. When the voltage of the positive end (pin 5) is greater than the negative end (pin6), the output of the op-amp(pin 7) will send the voltage signal to signal out 1 [2].

B. Motor Drive circuit

The working of the motor is mainly driven by PNP and NPN transistors here. Figure 2 shows the motor drive circuit. 2 PNP and 2 NPN transistors have been used for sending the signal to the motor for forward and reverse movement. 4 BJT transistors have also been used for the input of signals from the sensor circuit. A 12 volts DC battery is used for supplying power [3]. The voltage signal from "signal in 1" is passed through BC547. From here one signal is passed to D882 where one end of the output is taken. The other signal travels B772 via BC 547 where another end of output is taken. Voltage signal from "signal in 2" is passed through another BC 547. From here, one output goes to D882 for the output. The other output goes to another BC547 and finally to B772 where the other ends of output is taken. A signal from the switching circuit is also sent to the motor driving circuit. This terminal is connected with a 1N4148 diode and a BC 547 transistor [2]. When this terminal passes signal, the signals from "signal in 1" and "signal in 2" will not be collected. This helps in bringing back the position of the motor to initial position, i.e. the direction from where the sun rises. Below is the figure of the motor driving circuit.

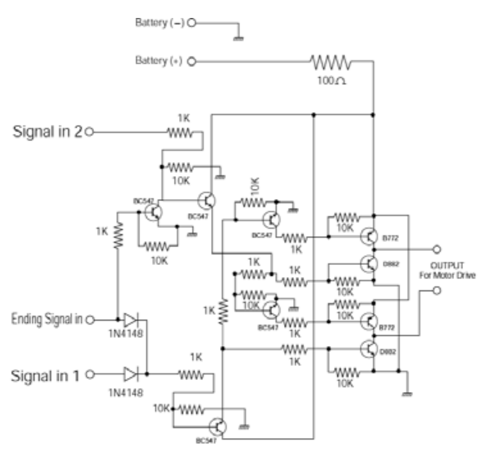

Fig 2: Motor drive circuit

C. Switching Circuit

A switching circuit has been used so that we can bring the tracking board to the initial position after the sun has set. The circuit is shown in figure 3, uses two switches at either end which will make contact with the lever after it has reached the maximum end. HA 17555 timer IC has been used for a short time delay. IC 4011 helps the output to the ending signal out [4].

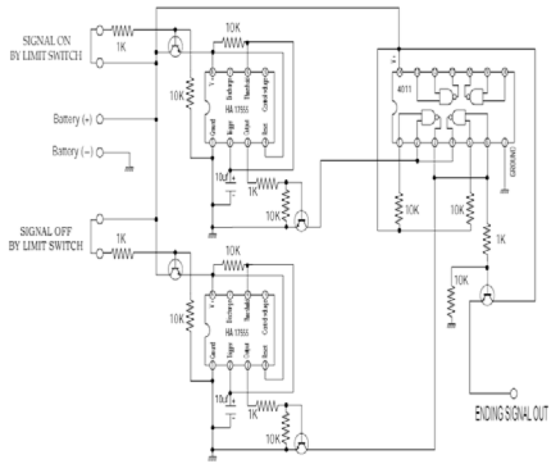

Fig 3: Switching Circuit

When the lever comes in contact with the signal on by limit switch, signals are passed to the timer so that a delay of few microseconds is created. Then, the output is transferred to IC4011 where NAND operation takes place. Finally a positive signal is sent to the ending signal out which is connected to the input of motor driver circuit [4]. As the lever comes in contact with the signal off by limit switch, signals are passed to another timer for a few microseconds delay. The output from here travels to the IC4011 for another NAND operation. Finally a negative output signal is generated at the ending signal out.

3. DESIGN ANALYSIS

The hardware used was separated into different stages while developing the whole system. The portions consisted of sensor circuit, motor driving circuit and a switching circuit.

A. PCB (Printed Circuit Board) Development

After the individual circuits had been devised and tested on breadboard, a printed circuit board (PCB) was developed with an external help. Figure 4 shows the layout of the circuits on PCB board.

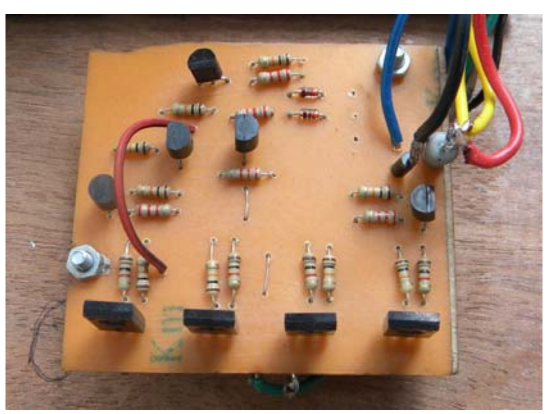

Fig 4: PCB board

Figure 4 shows the layout of the motor drive circuit on the PCB board. The circuit diagram shown in Fig 2 is implemented on this board.

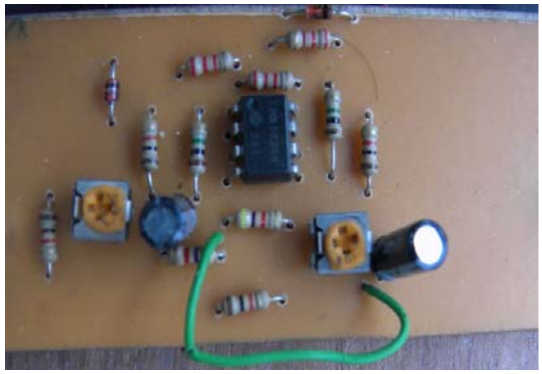

Fig 5: Sensor Circuit

The sensor circuit has been discussed in sensor circuit section. The above picture is the implementation of this circuit diagram on the PCB board. The resistors, capacitors, LDR and the non-inverting op-amp IC can be seen here clearly.

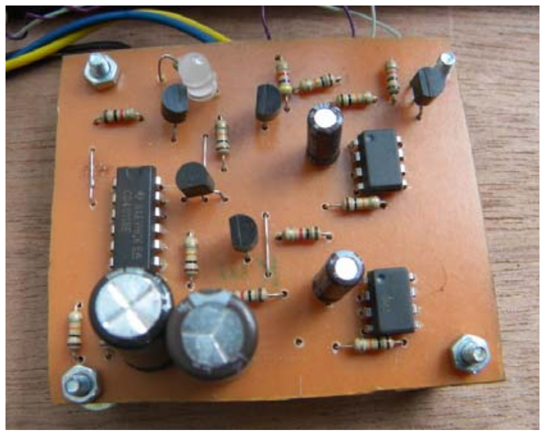

Fig 6: Switching Circuit

At the end figure 6 is the implementation of switching circuit as discussed in the switching circuit section. A small light is being used here. This light will indicate whether the tracker is at the initial position or not.

B. System Design

After developing the circuits on the PCB, it was time for designing the full mechanical system. A wooden board was used as a board to support the full system. Fig 7 shows the front view of our system.

Fig 7: Tracking system front view

The arrow in fig 7 indicates the LDR sensors. A plastic black panel is used to mount them on. As the light falls on the sensors, the panel moves in the direction of sensor which placed the panel in the direction of the maximum intensity.

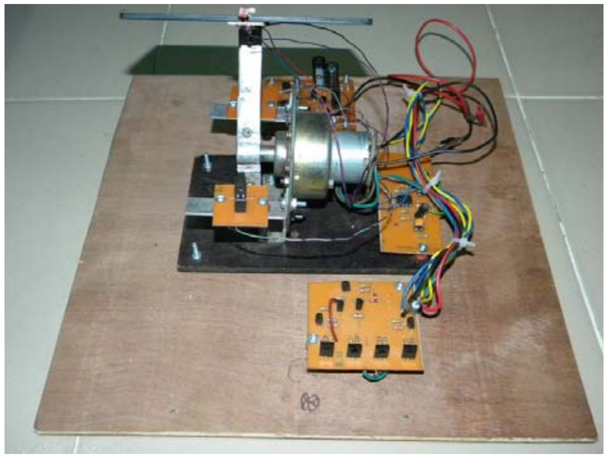

Fig 8: Tracking Device backside view

Fig 8 shows clearly the backside view of the model. It can be seen that the panel is attached to a lever that is fixed to the shaft of the DC motor. Fig 9 clearly shows the side view of the tracker. The DC motor moves the panel.

Fig 9: Side view of tracking device

A 12 Volts DC power supply is used to supply power to the circuit. For our experimental model we have used the battery of an UPS which provides a 12 Volts DC supply.

For the implementation the following things are being followed:

- Locating the position of the sun through sensory devices.
- Positioning the board by using motors, such that the sun's rays always strike the board normal to its surface.
- Bring back the position of the board to initial position using a switching device.

4. PERFORMANCE ANALYSIS

Our designed system has a quite significant outcome as we measure the performance our tracking system over a fixed system. Fig. 10 shows a performance graph of our designed tracking system over a fixed system. The measurement was taken from 9:30 am to 3:30 pm. In this graph it is clear that the efficiency with solar tracking methodology is near about 7% percent higher than with fixed angle [5].

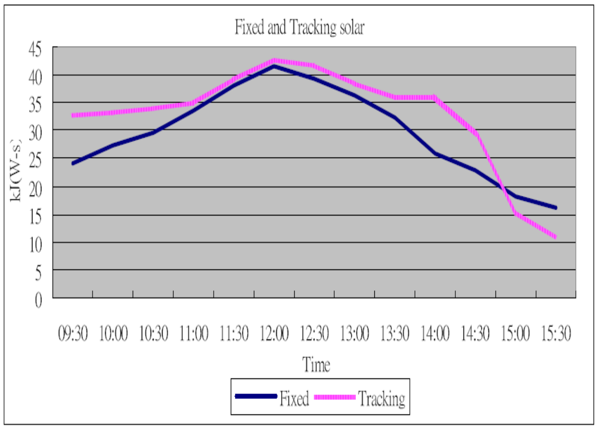

Fig.10: The power generation comparison type and tracking systems

Fig 11 shows the monthly output of 1KW AC array. From the histogram we can clearly see the seasonal variations in the output and also can observe the increasing output of a full tracking solar panel with respect with a stationary solar system.

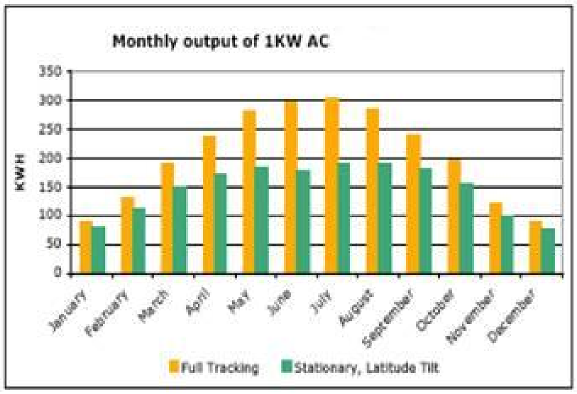

Fig 11: Full tracking vs Stationary tracking

5. ADVANTAGES OF THE SYSTEM

Our developed model has the following advantages make it an ideal model for research.

- Cheap in developing. The total costing of the project was merely around Tk.5000 including the cost resulting in the faults. Thus making the project more cost efficient.
- Real time response. The movement of the panel is real time as light falls on the panel. This was tested using a powerful torch. The panel moves in the direction as the torch is moved.
- Software programming and microcontroller avoided. Many of the tracking devices worked on so far have used microcontrollers and software programming. But we have achieved to avoid these two sections in our work to make it cost effective.
- The system is very easy to construct as all this chips and devices are available in the market.

6. CONCLUSIONS

The proposed solar tracking power generation system can track the sun light automatically. Thus, the efficiency of solar energy generation can be increased. Experimental work has been carried out carefully. The result shows that higher generating power efficiency is indeed achieved using the solar tracking system. Finally the work was completed with a successful implementation. We have not measured any performance analysis of our system with other existing tracking system. Because, our main goal was to build a cost effective tracking system. So the performance may vary with other tracking system. Our system is the simplest form of tracking device was designed that was cost effective, fast response and easy to construct.

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