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Implementation of a Microcontroller based Low-Cost Dual-Axis Solar Tracker for Efficiency Enhancement of Installed System

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Abstract - *Here in this work efforts were made to exploit the potentials of solar energy by developing a working prototype for the dual-axis solar tracking system. The dual axis-solar tracker is much more efficient than the single-axis solar tracker as it orients its position in both the directions so as to keep track of the Sun's position throughout the day. This system was developed around a high performance eight bit microcontroller platform ATmega32 that acts as a computational machine to make appropriate decisions to control the actuators. These actuators help aligning the solar panel in proper position. For sensing the intensity of light light-dependent-resistors were deployed here. The system was tested multiple times to achieve the desired functionality and greater accuracy levels.*

Key Words: Solar tracker, Dual-axis tracking, AVR, Microcontroller, LDR, Renewable Energy, etc.

1. INTRODUCTION

Today the World has been facing the crisis of energy due to exhausting reserves of conventional and non-renewable sources of fuel on this earth along with other associated problems like global warming, rapid increase of green house gases in atmosphere, etc. The rate of depletion of fossil fuels is already at an alarming level. To fulfill this ever increasing World's energy needs there is an acute demand to research out and develop alternative sources of energy. Also there is a need to increase awareness among the people by the governments to promote maximum use of clean and green renewable energy instead of harmful fossil fuel consumption to generate energy. Thus, the solar energy which is considered as one of the cleanest source of energy is catching a lot of attention worldwide. Some countries like Germany, China and United States are listed as top countries today that have highest installed capacity of solar power. The cost of installing PV systems are dropping down and also the governments are providing subsidies to the consumers and organizations to promote the maximum use of renewable energy, however, the efficiency of PV based power is still coming under a hot area of research and this field requires more rigorous research. It is acknowledged that solar systems are widely accepted as the main method for converting the sun energy into the most transportable form of energy i.e. electrical energy. Considering the above mentioned facts, to minimize the rapid depletion of non-renewable sources of energy, we researched to find out the ways to meet the rising power demands by some other alternative sources of energy preferably those which are cheap or free, easy to harness, available in plenty and are renewable. As long as this earth would exist, the solar energy is there to give us regular supply of its radiations. The sun will shine for several million more years, therefore, renewable sources represent an unlimited potential of energy for the future.

2. OBJECTIVE OF WORK

The objective of the work was to design and develop a microcontroller based prototype for an automatic dual-axis solar tracker. These kind of solar trackers are becoming popular nowadays as they prove to be much more efficient than single-axis solar trackers in collecting the solar energy from Sun and converting it into electrical energy. As the dual-axis solar tracker orients itself in such a way in all the directions to track the Sun with high precision, so it deployed two actuators for controlling the panel's position and multiple sensor inputs were used with proper feedback mechanism.

3. SYSTEM WORKING PRINCIPLE

A prototype system was designed and developed to implement a dual-axis solar tracker in order to enable the solar panels to always face the sun orthogonally. This system was developed around an eight-bit high performance microcontroller which acted as a computational platform here. There were multiple sensors deployed which feeds the microcontroller for measuring certain parameters and make appropriate decisions for controlling the stepper motor based actuators. The developed prototype also deployed a medium size solar panel to be controlled by these actuators only.

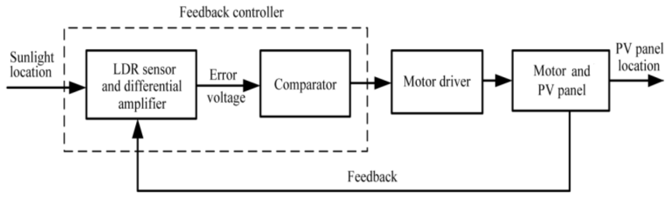

Fig.- 1: Implemented System

4. SYSTEM ARCHITECTURE

The implemented system utilized an Automated Tracking Mechanism instead of some Adaptive Mechanism or Predefined Motion. The developed hardware prototype was a closed loop control system which uses sensors data as a feedback to compensate for any errors and align the system accordingly. As it could be observed from the block diagram given below in this solar-tracker the sensors used to measure certain physical parameters acted as system inputs whereas the stepper motors used for actuation purpose acted as system outputs. The microcontroller acts as the brain of the system which was responsible for scanning each sensor continuously on time-shared basis and after measuring these parameters analyze the values obtained and finally make assessment as per the conditions to send commands to the stepper motors. These stepper motors oriented the solar platform attached to it.

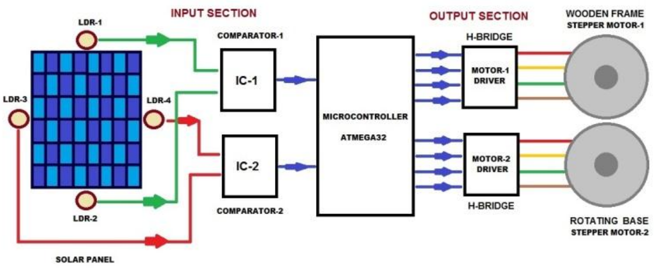

Fig.-2: System Architecture

5. METHODOLOGY ADOPTED

Here in this section the methodologies followed to design and implement this system using different hardware and software tools were discussed.

5.1 System Components

Sr. No.	Name of Component	Quantity
1	Microcontroller ATmega32	01
2	40-pin IC base	01
3	Crystal Oscillator 16MHz	01
4	Resistor 10K	02
5	Resistor 15K	02
6	Resistor 47K	02
7	Preset 20K	02
8	Preset 100k	02
9	Stepper Motor	02
10	LDR	04
11	Comparator IC	02
12	H-Bridge IC	02
13	General Purpose PCB	01
14	5V DC Adaptor	01
15	Connecting Wire	01 meter
16	Solar Panel	01

Table-1: List of Components

5.2 Schematic Diagram

The schematic diagram shown below was designed in the Proteus software. This CAD tool software is very popular worldwide for PCB designing and carrying out microcontroller based programmable circuit simulations. It has a very wide library of components and is very easy to use. As shown below we designed a schematic here for our solar tracker project and the system was developed around a high performance 8-bit microcontroller Atmega32. The microcontroller was interfaced to a circuit providing the input signals driving another circuit to get the desired outputs. The input section consists of four LDRs connected via comparators and four inverters to the microcontroller general purpose input/ output (GPIO) pins. The microcontroller was programmed to read these input signals and make decision to send appropriate command signals to the actuators in the output section. The actuators chosen here were two stepper motors. These stepper motors were driven by two H-bridge circuits. The microcontroller send command signals to its GPIO pins to drive these H-bridge circuits. Stepper motors rotates in stepped order so the movement was angle controlled to orient the solar panel according to the Sun's position.

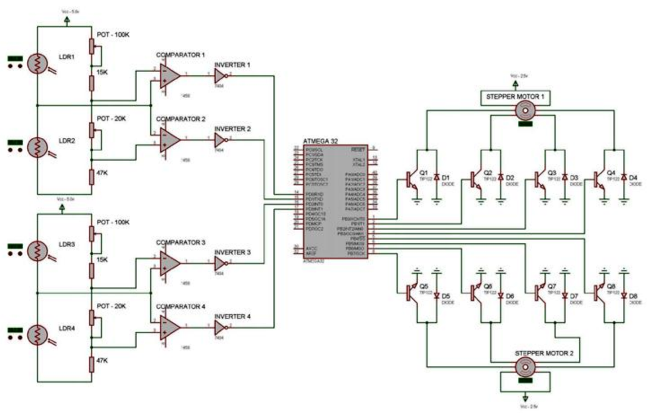

Fig.-3: Schematic Diagram of Implemented System

5.3 SYSTEM WORK FLOW

The single layer pin-through-hole (PTH) PCB layout was designed in PROTEUS. The layout editor took the reference of schematic design and generated component packages corresponding to each component chosen into the schematic design. Therefore, proper care was taken while choosing the components keeping in view of their package including parameters like type of package required (DIP, SMD, etc.) , pitch size, area, pad size, pad shape and drill hole, etc. The PCB tracks were designed in Bottom layer only. Component placement and routing is the most important aspect for a PCB design and there were other parameters too worth consideration like track size, track pitch, parasitic capacitance, track resistance, proper grounding, etc.

6. FLOW CHART

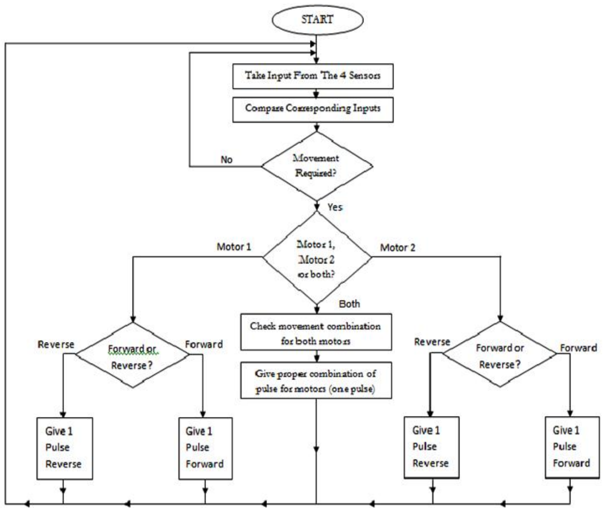

Fig.-4: System Work Flow

7. EXPERIMENTAL SETUP & RESULTS

Here the developed prototype of dual-axis solar tracker was demonstrated. As could be observed from below given figures, the solar panel was suspended in a wooden frame. This frame was driven by a stepper motor and it oriented the solar panel in just two directions. For other two directions second stepper motor was deployed into the base of this wooden frame. As it was a dual-axis solar tracker, the base was not fixed but made to rotate to align the solar panel at appropriate angles. We carried out a lot of iterations and this solar tracking system was made a fully functional prototype.

Fig.-5: Upper Frame of the Prototype

Fig -6: The Rotating Base of the Prototype

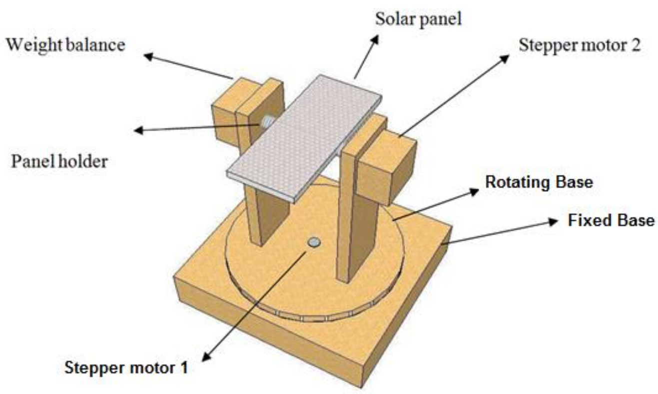

Fig.-7: The Complete Prototype

Fig.-8: The Developed Prototype

8. CONCLUSION DRAWN

Here in this work a dual-axis solar tracker was realized. It was tested and calibrated multiple times to get the desired results. It was found that a dual-axis solar tracker is more efficient than a single-axis solar tracker. Multiple tests were carried out and from the test, we get the clear effects to prove that moveable arrays of solar panel can enhance the efficiency around 40% and more which is almost 1.5 times extra than the quantity we get from a fixed panel. Therefore, it could be concluded that it's possible and practical to make the solar panel portable to make it greater green because at the cutting-edge second of the world, even a 1% development would be worthy – and the automatic solar tracking system can be of 40% greater efficient than constant panels; the perfect manner to reap greater sun energy.

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