An Intelligent Maximum Power Generation by Dual Quad Axis Solar Tracking Systems using Embedded Technology

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Abstract — Solar power generation had been employed as a renewable energy for years ago. Residents that use solar power as their alternative power supply will bring benefits to them. When the intensity of light is decreasing, this system automatically changes its direction to get maximum intensity of light. Light dependent photo resistors are used as the sensors of the solar tracker. For rotating the appropriate position of the panel, a DC motor is used. The sun tracking system is designed in this project, offers a reliable and affordable method of aligning a solar panel with the sun on dual quad axis. This project is based on AVR Microcontroller with a simple circuit and sun tracking software.

Keywords— AVR Microcontroller, LDR, Relay, Arduino Software, Battery, Solar Panel.

I. INTRODUCTION

Solar energy is the most readily available source of energy. It is free and is the most important form of non-conventional sources of energy because it is non-polluting and therefore helps in lessening the greenhouse effect. Solar energy is the technology used to harness the sun's energy and make it usable. It is lauded as an inexhaustible fuel source that is pollution free and often noise free. Solar energy has been used since prehistoric times, but in a most primitive manner. Before 1970, some research and development was carried out in a few countries to exploit solar energy more efficiently, but most of this work remained academic. After the dramatic rise in oil prices in the 1970's, several countries began to formulate extensive research and development programs to exploit solar energy. India is one of the few countries with long days and plenty of sunshine, hence solar energy can be harnessed easily. Solar thermal energy is being used for heating water for both industrial and domestic purposes. Solar energy can be used to meet our electricity requirements. Through Solar Photovoltaic (SPV) cells, solar radiation gets converted into DC electricity directly. This electricity can either be used as it is or can be stored in the battery. This stored electrical energy can then be used at night. Sunlight has two components, diffused sunlight that has 10% of solar energy and the direct sunlight that carries 90% of solar energy. SPV can be used for a number of applications including domestic lighting, street lighting, village electrification, water pumping etc. If the means to make efficient use of solar energy could be found, it would reduce our dependence on non-renewable sources of energy and make our environment cleaner. Another way of harnessing the solar radiation is by making use of solar panels. The solar panels absorb the energy of the sun which is later used for other purposes. Such systems are available in the market and are being used in homes and factories. Solar energy use has surged at about 20 percent a year over the past 15 years, thanks to rapidly falling prices and gains in efficiency.

II. METHODOLOGY

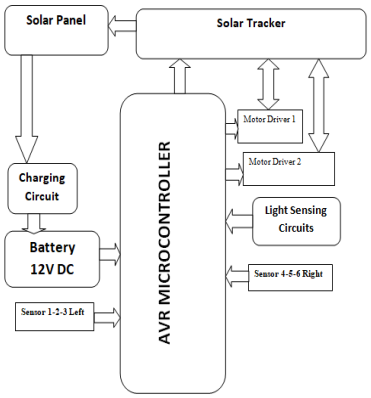

Fig 1: Block Diagram

Basic design flow of project is show in the figure 1. It consists of Solar panel, Solar Tracker, AVR Microcontroller, Charging circuit, Battery, Light intensity detection sensor. left sensor, right sensor, two motor driver. AVR Microcontroller is heart of the project which is control the solar panel directions. Light sensing circuits are used to sense the high intensity direction and depending on light intensity, AVR Microcontroller control the solar panel through Solar Tracker unit. Solar energy is stored in battery through the charging circuit. Which is used for any ac /dc devices to on /off.

1. *HARDWARE SPECIFICATIONS*

❖ Solar Panel:

A **solar cell**, or **photovoltaic cell**, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels. Solar cells are described as being photovoltaic irrespective of whether the source is sunlight or an artificial light. They are used as a photo detector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

❖ Solar Tracking Sensor:

LDR based Solar tracking sensors are used in this project. A **photoresistor** or **light-dependent resistor** (**LDR**) or **photocell** is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.

❖ AVR Microcontroller:

AVR Microcontroller is heart of the project. Embedded C language is used to do the programming. The **AVR** is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to one-time programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time.

What's special about AVR?

They are fast: **AVR microcontroller** executes most of the instructions in single execution cycle. AVRs are about 4 times faster than PICs, they consume less power and can be operated in different power saving modes. Let's do the comparison between the three most commonly used families of microcontrollers.

❖ Relay:

Relays are nothing more than electrically operated switches. Relays use an electromagnetic coil to pull the poles of the switch into position. Most relays return to the normally closed position by a spring when the coil is de-energized, so relay contacts are usually identified in the same way as those of a momentary contact switch. Note that in the diagram the coil polarity is indicated. Relays will generally operate just as well regardless of coil polarity, however it does come into play for one important reason. Since a relay is an electromagnetic device, the coil generates what is known as fly back when it de-energizes. This is a phenomenon common to all inductive devices (which an electromagnet is). When the coil is de-energized the magnetic field surrounding it collapses. This collapsing field cuts through the coil windings and induces a current in the opposite direction from that which charged the coil. This reverse current travels back through the wiring to the current source. If that source happens to be a logic gate, a microcontroller output, or some other sensitive device it can damage the device or otherwise cause it to malfunction.

For this reason it is common practice to place an ordinary diode across the coil terminals. Any normal diode will work. The diode allows current to charge the coil, yet it will block any reverse current. I have found that the easiest way to determine the proper polarity of the diode is to simply clip it onto the coil terminals and energize the relay. If it energizes, then the diode is aligned properly. If it does not, simply flip the diode around.

2. *SOFTWARE SPECIFICATIONS*

❖ ARDUINO SOFTWARE

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, 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. Arduino projects can be stand-alone, or they can be communicate with software running on your computer (e.g. Flash, Processing, MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free.

The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

❖ Embedded C:

Embedded C programming typically requires nonstandard extension to the C language in order to support enhanced microcontroller features such as fixed point arithmetic, multiple distinct memory banks, and basic I/O operations.

III. WORKING

The proposed tracking system does tracking of sunlight more effectively by providing PV panel rotation in two different axis. In dual-axis tracking system optimum power is achieved by tracking the sun in four directions. In this way we can capture more sun rays. Movement in two axis is explained with the help of circuit design which is explaining basic idea behind dual axis tracking. The dual-axis solar tracker follows the angular height position of the sun in the sky in addition to following the sun's east-west movement. The dual-axis working is similar to single axis but it captures the solar energy more effectively by rotating in the horizontal as well as the vertical axis.. The tracker model is composed of four LDR sensors, two DC motors and AVR microcontroller. One set of sensors and one motor is used to tilt the tracker in sun's east - west direction and the other set of sensors and the other motor which is fixed at the bottom of the tracker is used to tilt the tracker in the sun's north-south direction. The DC motors are basically performing function of sun tracking. Upper panel holder DC motor tracks the sun linearly and base DC motor tracks the parabolic displacement of sun. These DC motors and sensors are interfaced with a microcontroller which is controlling DC motors on the basis of sensor's input.

LDR sensors sense the light and sends signal to microcontroller. Microcontroller is doing comparison of signals 2 received from LDR sensors and on the basis of stronger signal it is deciding rotation direction of DC motors. Dual Axis tracker control is explained with the help of circuit diagram shown above. The circuit diagram is showing that LDR sensors after sensing the light forward the signal to Microcontroller. Microcontroller is intelligent device which is taking actions on the basis of sensor input and activating the motor driver's circuit accordingly. Now suppose if sun changes it location and moves from east to west, it will cause light intensity to be different on one sensor as compared to other one. On the basis of light intensity difference on sensors, controller activates driver circuits and moves dc motors to new positions where light falling on sensor pairs is same. The same process will keep on with change in sun's location in the sky. As a result this proposed model is able to capture more sun rays and system's solar energy conversion capability is greatly enhanced. Controller is performing signal comparison and is the main deciding element. Control algorithm for controller is shown in figure. Algorithm starts with taking data from sensors. Sensors output is analogue which is converted to digital signals. This task is performed using analogue to digital converter (ADC). Digitized signals are forwarded to microcontroller. After collecting digitized signals, it decides about the movement direction and step angle of dc motors. Controller algorithm is showing that microcontroller drives dc motors only if sensor light sensing is not equal to each other and if sensor signals are equal. It goes to start of algorithm. This process is repeated until light falling on sensor pairs is equal and PV panel is adjusted in a position for optimum power. The voltage generated by solar panel is varying and needs to be regulated. A regulator can be used after the solar panel which may regulate the voltage coming from solar panel. Tracker circuitry requires power supply for its working and for this purpose supply is provided by generated solar energy. There is no need to provide external power supply which makes our system economical and cost effective too. The purposed model can also e used as a standalone system by introducing battery storage and proper control of storage system. Battery storage is 3 controlled on the basis of generated voltage. Charging and discharging events for storage are decided on the basis of generated voltage.

The tracking system is designed such that it can trap the solar energy in all possible directions. Power absorbed is stored in a rechargeable battery, so power can be used whenever required.

In the future the AVR Microcontroller ATMEGA-328 IC is used & embedded C code is written in this project, which is reprogrammable. In the future we can enhance it more application on a same development board.

IV. ALGORITHM

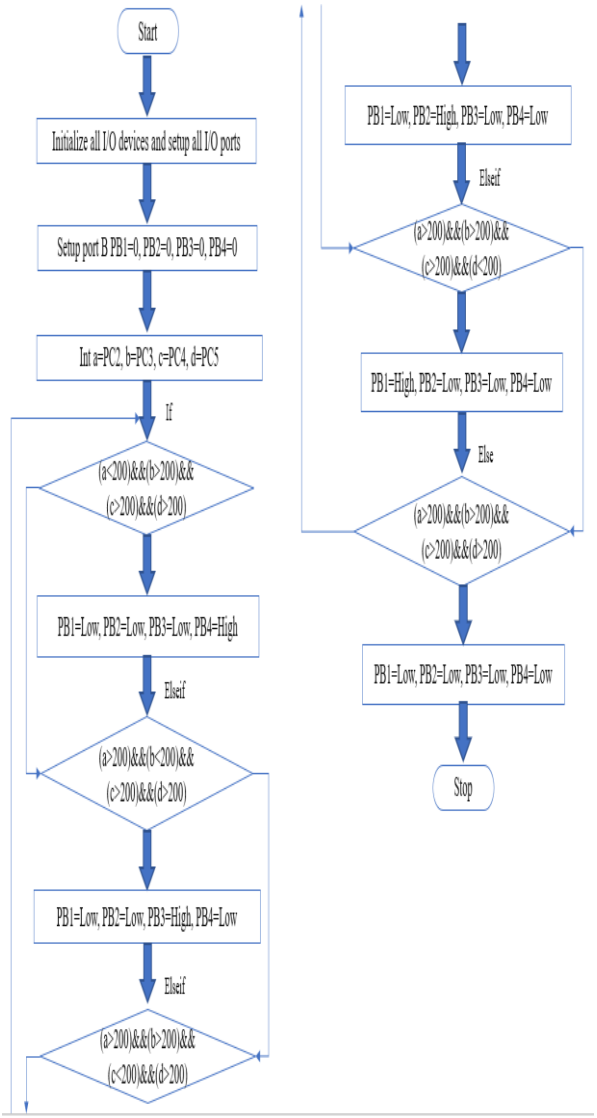

Fig 2: Flowchart

Fig 2 depicts the flow of the project. Flowchart implies the following.

- First step is to initialize all I/O devices and setup I/O ports.
- Assign analog LDR outputs and PWM servomotor inputs to AVR Microcontroller board.
- If center LDR = 0, then delay (longer).
- Check alignment (Simultaneously for north-south and east-west).
- If up (LDR) greater than center and down (LDR) lesser than center, then increase position of servomotor1 by 1 unit. Give delay.
- Else if up (LDR) lesser than center and down (LDR) greater than center, then
- decrease position of servomotor1 by 1 unit. Give delay.
- (Simultaneously along with step 5) If right (LDR) greater than center and left
- (LDR) lesser than center then increase the position of servomotor2 by 1 unit. Give

- delay.
- Else if right (LDR) is lesser than center and left (LDR) greater than center then
- decrease position of servomotor2 by 1 unit. Give delay.
- Go to Step 4.

V. RESULT

AVR Microcontroller based maximum power generation using dual-quad axis solar panel, the panel moves according to sun's movement using LDRs, motors and microcontroller.

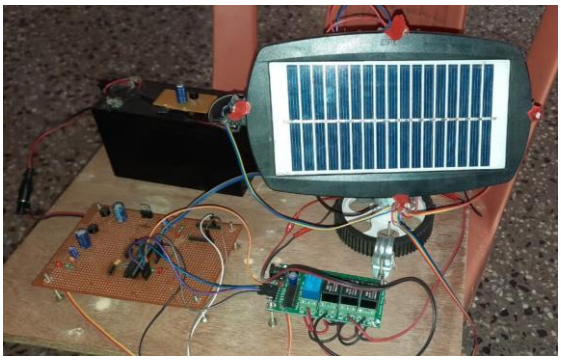

Fig 3: Experimental Setup

VI. CONCLUSION

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. The tracking system is designed such that it can trap the solar energy in all possible directions. Power absorbed is stored in a rechargeable battery, so power can be used whenever required.

ACKNOWLEDGMENT

This work is supported by our project guide, Harish s v, assistant Professor, ECE, NIEIT. We are thankful to the guide and faculties of our college who helped us in proposing this system.

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