Arduino-based Design Methodology for Automatic Solar Tracker

B. Jyothi[1], Ch. Neha Vasavi Simha[1]

[1]Department of EEE, SreeDattha Institute of Engineering and Science, Hyderabad, Telangana, India.

ABSTRACT

Energy crisis is the most important issue in today's world.Conventionalenergy resources are not only limited but also the prime culpritforenvironmental pollution.Renewable energy resources are getting prioritiesin the whole world to lessen the dependency on conventional resources. Solarenergyis rapidly gaining the focus as an important means of expanding renewable energy uses. Solar cells those convert sun's energy intoelectrical energy are costly and inefficient.Different mechanismsare applied to increase the efficiency of thesolar cell to reduce the cost.Solar tracking system is the most appropriate technologyto enhance the efficiencyof thesolar cells by tracking the sun. Amicrocontroller-based design methodology of an automaticsolar trackeris presented in this paper.Light dependentresistors areused as the sensors of the solar tracker.The designed tracker has precise control mechanism which will provide three ways of controlling system. A small prototype of solar trackingsystem is also constructed to implement the design methodology presented here.

Keywords: Photovoltaic cell, solar tracking, photo resistor, ATmega 328, DC motor.

1. INTRODUCTION

One of the most promising renewable energy sources characterized by a huge potential of conversion into electrical power is the solar energy. The conversion of solar radiation into electrical energy by Photo-Voltaic (PV) effect is a very promising technology, being clean, silent, and reliable, with exceedingly small maintenance costs and small ecological impact. The interest in the Photo Voltaic conversion systems is visibly reflected by the exponential increase of sales in this market segment with a strong growth projection for the next decades. According to recent market research reports carried out by European Photovoltaic Industry Association (EPIA), the total installed power of PV conversion equipment increased from about 1 GW in 2001up to nearly 23 GW in 2009.

The continuous evolution of the technology determined a sustained increase of the conversion efficiency of PV panels, but nonetheless the most part of the commercial panels have efficiencies no more than 20%. A constant research preoccupation of the technical community involved in the solar energy harnessing technology refers to various solutions to increase the PV panel's conversion efficiency. Among PV efficiency improving solutions we can mention solar tracking, optimization of solar cells geometry, enhancement of light trapping capability, use of new materials, etc. The output power produced by the PV panels depends strongly on the incident light radiation.The continuous modification of the sun-earth relative position determines a continuously changing of incident radiation on a fixed PV panel. The point of maximum received energy is reached when the direction of solar radiation is perpendicular on the panel surface. Thus, an increase of the output energy of a given PV panel can be obtained by mounting the panel on a solar tracking device that follows the sun trajectory. Unlike the classical fixed PV panels, the mobile ones driven by solar trackers are kept under optimum insolation for all positions of the Sun, boosting thus the PV conversion efficiency of the system. The output energy of PV panels equipped with solar trackers may increase with tens of percent's, especially during the summer when the energy harnessed from the sun is more important. Photo-Voltaic or PV cells, known commonly as solar cells, convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in that they give off no noise and require practically no maintenance. A tracking system must be able to follow the sun with a certain degree of accuracy, return the collector to its original position at the end of the day and track during periods of cloud over.

Solarpaneldirectlyconverts solar radiation into electrical energy. Solar panel is mainly madefrom semiconductor materials.Siusedasthemajor component of solarpanels, whichismaximum 24.5%efficient [2]. Unless highly efficient solar panels are invented, the only way to enhance the performance of a solar panel is to increase the intensity of light falling on it. Solar trackers are the most appropriate and proven technology to increase the efficiency of solar panels through keeping the panels aligned with the sun's position. Solar trackers get popularized around the world in recent days to harness solar energy in most efficient way. This is far more cost-effective solution than purchasing additional solar panels [3]. In this paper the design methodology of a microcontroller based simple and easily programmed automatic solar tracker is presented. A prototype of automatic solar tracker ensures feasibility of this design methodology.

2. TECHNOLOGY OF SOLAR PANEL

Solar panels are devices that convert light into electricity. They are called solar after the sun because the sun is the most powerful source of the light available for use. They are sometimes called photovoltaic which means "light-electricity". Solar cells or PV cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charge layers. A solar panel is a collection of solar cells. Although each solar cell provides a relatively small amount of power, many solar cells spread over a large area can provide enough power to be useful. To get the most power, solar panels must be pointed directly at the Sun. The development of solar cell technology begins with 1839 research of French physicist Antoine-Cesar Becquerel. He observed the photovoltaic effect while experimenting with a solid electrode in an electrolyte solution. After that he saw a voltage developed when light fell upon the electrode.According to Encyclopedia Britannica the first genuine for solar panel was built around 1883 by Charles Fritts. He used junctions formed by coating selenium (a semiconductor) with an extremely thin layer of gold. Crystalline silicon and gallium arsenide are typical choices of materials for solar panels. Gallium arsenide crystals are grown especially for photovoltaic use, but silicon crystals are available in less-expensive standard ingots, which are produced mainly for consumption in the microelectronics industry. Norway's Renewable Energy Corporation has confirmed that it will build a solar manufacturing plant in Singapore by 2010 - the largest in the world. This plant will be able to produce products that can generate up to 1.5 Giga watts of energy every year. That is enough to power several million households at any one time. Last year the world produced products that could generate just 2 GW in total.

2.1. Evolution of Solar Tracker

Since the sun moves across the sky throughout the day, to receive the best angle of exposure to sunlight for collection energy. A tracking mechanism is often incorporated into the solar arrays to keep the array pointed towards the sun. A solar tracker is a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. When compare to the price of the PV solar panels, the cost of a solar tracker is relatively low. Most photovoltaic solar panels are fitted in a fixed location- for example on the sloping roof of a house, or on framework fixed to the ground. Since the sun moves across the sky though the day, this is far from an ideal solution. Solar panels are usually set up to be in full direct sunshine at the middle of the day facing South in the Northern Hemisphere, or North in the Southern Hemisphere. Therefore, morning and evening sunlight hits the panels at an acute angle reducing the total amount of electricity which can be generated each day.During the day, the sun appears to move across the sky from left to right and up and down above the horizon from sunrise to noon to sunset. To keep up with other green energies, the solar cell market must be as efficient as possible in order not to lose market shares on the global energy marketplace. The end-user will prefer the tracking solution rather than a fixed ground system to increase their earnings because:

- The efficiency increases by 30-40%.
- The space requirement for a solar park is reduced, and they keep the same output.
- The return of the investment timeline is reduced.
- The tracking system amortizes itself within 4 years.
- In terms of cost per Watt of the completed solar system, it is usually cheaper to use a solar tracker and less solar panels where space and planning permit.
- A good solar tracker can typically lead to an increase in electricity generation capacity of 30-50%.

3. PROPOSED SYSTEM

Solar energy is especially important means of expanding renewable energy resources. In this paper is described the design and construction of a microcontroller based solar panel tracking system. Solar is a nonconventional source of energy, considering this we have developed solar panels so that we can fulfill our electricity need. But due to revolution of the earth, solar source i.e. sun does not face the panel continuously hence less electricity is produced. The energy panel should face the SUN till it is present in a day. The problem above can be solved by our system by automatic tracking the solar energy. The block diagram below shows system architecture it consists of an LDR sensor senses max solar power which is being given to the Microcontroller through the ADC which digitizes the LDR output. Controller then takes the decision according to then algorithm and tilts the panel towards the direction of the max energy given by LDR with the help of DC Motor . The Motor is used to rotate the LDR to sense the max solar power. A Solar Tracker is basically a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. After finding the sunlight, the tracker will try to navigate through the path ensuring the best sunlight is detected. It is completely automatic and keeps the panel in front of sun until that is visible. Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum. Residential that uses solar power as their alternative power supply will bring benefits to them.

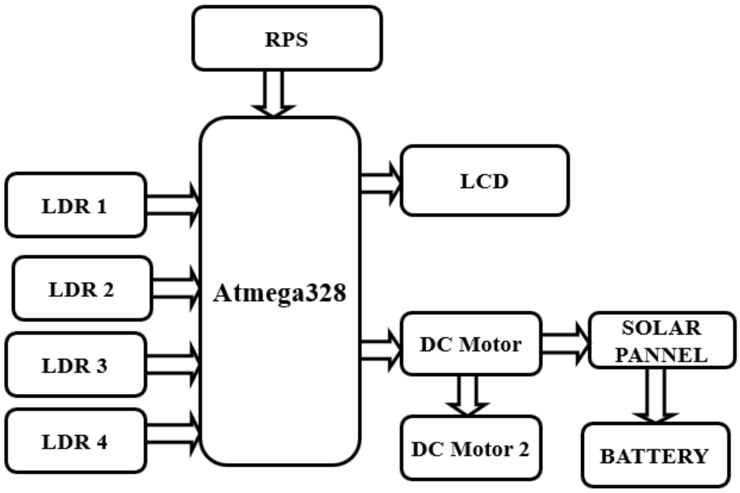

Fig. 1: Proposed automatic solar tracking system.

ISSN- 2394-5125 VOL 7, ISSUE 08 , 2020

The main objective of this project is to development of an automatic solar tracking system whereby the system will be caused solar panels will keep aligned with the Sunlight to maximize in harvesting solar power. The system focuses on the controller design whereby it will cause the system is able to tracks the maximum intensity of Sunlight is hit. When the intensity of Sunlight is decreasing, this system automatically changes its direction to get maximum intensity of Sunlight. LDR light detector acts as a sensor is used to trace the coordinate of the Sunlight by detecting brightness level of Sunlight. While to rotate the appropriate position of the panel, a DCgeared motor is used. The system is controlled by two relays as a DC-geared motor driver and a microcontroller as a main processor.

This project is covered for a single axis and is designed for low power and residential usage applications. From the hardware testing, the system can track and follow the Sunlight intensity to get maximum solar power at the output regardless motor speed.

3.1. Description of components

The major part of this electronics system is the micro controller. All theoperations are controlled by it. With the help of micro controller, you can align the solar panel according to the intensity of the sunlight. Another component is the rechargeable battery which is used to store energy which is received from the panel. The purpose of the charge control is to control the charging of the battery. Micro controller unit receives the status of the battery by the charge control unit. It has two sensors, each made up of LDR. Four LDRs constitute on unit and are placed at the four corners of the panel. LDR senses the intensity of sunlight and controller receives the output. Control unit decides in which direction the panel must be rotated to get maximum sunlight. Another unit of the sensor also consists of LDRs and used for the control of lightning load. The panel can be rotated in the desired direction by the DC motor.

3.2. Working

In our project we have use solar panel to convert the light energy into the electrical energy. The Sun change its position throughout the day that’s why we can’t able to utilize the whole light energy so we have made a tracking system in which solar panel can be rotate as per the sun changes its position. We have use the four LDR Sensor to sense the light and if the sun change its position then respective LDR Sensor sense the light and generate the highest voltage signal and this highest voltage signal fed to the comparator IC as well as remaining sensors also give its generated voltage level to the comparator IC. All voltage signal of the each LDR sensor that are compared by the LM324 are fed to the microcontroller. Microcontrollers receive the voltage signal from the any i/o pin of the controller and compares the each LDR output signal to with each LDR sensor output. When the controller find the Highest voltage level of any LDR sensor gives the instruction to the motor through the motor driver circuit to rotate the solar panel on the single axis in the direction of the LDR sensor which are generating highest voltage output. so, the Battery can recharge appropriately through the Solar panel. By using external two DC motors and by making connection in parallel we can move the solar penal in any direction. As by rotating the solar panel in the direction of the sun we utilize the maximum energy of the sun.

3.3. Advantages

- This automatic solar tracker is easy to implement since its construction is simple.
- With the implementation the proposed system the additional energy generated is around 25% to 30% with very less consumption by the system itself.

- The solar panel with the sun to extract maximum energy falling on its renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate.

4. EXPERIMENTAL SETUP AND RESULTS

The system is focusing on the controller design. The constructed system has been tested and some data from hardware measurement have been collected and discussed. Typical solar panel has been used and the purpose only to prove the designed system is able to operate accordingly. Therefore, the surrounding effects, for instance, weather condition are not seriously considered during hardware testing.

4.1. Arduino

Arduino Uno is a microcontroller board based on 8-bit ATmega328P microcontroller. Along with ATmega328P, it consists other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller. Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button.Arduino can be used to communicate with a computer, another Arduino board, or other microcontrollers. The ATmega328P microcontroller provides UART TTL (5V) serial communication which can be done using digital pin 0 (Rx) and digital pin 1 (Tx). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The ATmega16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. There are two RX and TX LEDs on the Arduino board which will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328P also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.

4.2. DC Motor

Almost every mechanical movement that we see around us is accomplished by an electric motor. Electrical machines are used for the converting energy. Motors take electrical energy and produce mechanical energy. Electric motor is used to power hundreds of devices we use in everyday life. An example of small motor applications includes motors used in automobiles, robot, hand power tools and food blenders.

A motor driver Integrated circuit (L293D) chip is designed to control and regulate motors.It is a dual H-bridge motor driver Integrated Circuit. They are generally used in mechanics and robotics. It acts as an interface between motor and Arduino microprocessor in the circuit. L293D, L293NE are most used motor driver Integrated circuits from L293 series. L293D is designed to control up to maximum of two direct current motors simultaneously when they are integrated with Arduino Uno. It helps to regulate the flow of current before it finally reaches the motor. It becomes a necessity and need to use IC L293D due to different requirement of current and voltages by microprocessors (low) and 5V DC motor (high) as it acts as a moderator and balances the flow of current. It protects the circuit from overload current and provides protection against overload temperature. Current should not be directly supplied to the motor because it can damage the motor or even the microcontroller. It has an output capability and provides bidirectional current of 600 mA per channel. The maximum or peak current which can flow through per channel as output is 1.2 Amp. It has Enable facility and internal clamp diodes. Input voltage is up to 1.5V-36V which is also high noise immunity (logical "0").

Various and un-similar PWM signals are received because a motor driver IC interfaces with the microcontroller. A motor driver IC is also responsible for achieving required outputs for the speed variation of the DC motor.

4.3. LCD

LCD is liquid crystal display technology works by blocking light. Specifically, it is made of two pieces of polarized glass that contain a liquid crystal material between them. A backlight creates light that passes through the first substrate. It is used for display purpose.

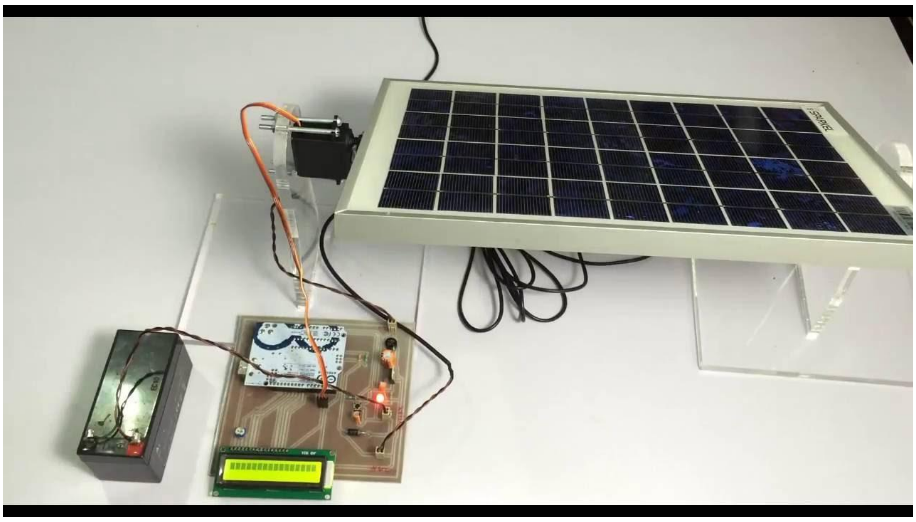

Fig.2: Hardware setup of solar tracking system.

5. CONCLUSIONS

This article implemented a solar paneltrackingsystem with the aim to trackthe position of the sunfor better efficiency of the solar panel.In addition, our work can be executed on an industrial scale which be beneficial to developing countrieslikeNigeria andSub-SaharaAfricacountries.Our recommendation for future works is to consider the useof more sensitive and efficient sensors which consume less power, and which are also cost effective. This would increase the efficiency while reducing cost.

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ISSN- 2394-5125 VOL 7, ISSUE 08 , 2020

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