ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

IMPROVED STRUCTURE OF AUTOMATIC SOLAR TRACKING SYSTEM

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ABSTRACT

Energy crisis is the most important issue in today's world as demand for electrical energy increasing over the years. Conventional energy sources are not only limited but also hazardous to environment. Therefore, usage of non-conventional energy sources are getting more popular to lessen the dependency over conventional energy sources. In the recent years, solar energy has been established as one of the chief non-conventional energy sources. Owing to the usage of solar energy, it has become necessary to develop some methods for the better use of solar energy. This paper presents one such resurgent method: Solar Position Tracking. A Arduino controller based method of solar tracking is presented in this paper. Light dependent resistors are used as sensors to determine the start and stop point of tracker. A small prototype of solar tracking system is also constructed to implement the design methodology.

KEYWORDS: Photovoltaic panel, Arduino controller, Light dependent resistors, IC-L298, Stepper motor, Solar Tracker.

INTRODUCTION

Presently, the chief sources of energy available for our world are fossil fuels. Considering the rate at which fossil fuels are consumed today, studies suggest that most of the known reserves of fossil fuels are likely to get exhausted by the end of century. Energy crisis, as evinced by frequent power cuts and rising fuel prices, is a major concern in the world. To provide a sustainable power production and safer world to the future generation, there is a growing demand for energy from renewable sources like wind, solar, geo thermal and ocean tidal wave.

The sun is the prime source of energy, directly or indirectly, which is also the most renewable systems. Among all renewable systems, solar energy has a great chance to supplant the usage of conventional energy sources. Solar panel converts directly from solar energy in to electrical energy. Solar panels are mainly manufactured mainly from the semiconductor materials such as silica with over all maximum efficiency of 24%. Unless, the high efficient solar panels invented, the only way to enhance the performance of the solar panel is to increase the intensity of light falling on it. Solar trackers are the most appropriate and proven technology to improve the performance of solar panel by aligning the solar panel to the direction of sun throughout the day. Solar trackers are getting more popularized now a day's as they provide a cost effective solution than purchasing additional solar panels.

In this paper, the design methodology of Arduino controller based simple and easily programmed automatic solar tracker is presented.

PHOTOVOLTAIC TECHNOLOGY

Photovoltaic materials convert sunlight directly in to electrical energy. Becquerel discovered the process of producing electricity using sun light in a solid state material but it takes a century for scientists to truly understand this process. Scientists eventually learned that photovoltaic effect causes certain materials to convert sunlight in to electrical energy at atomic level. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the step involves the photo electric effect from which a second electro chemical process take place involving crystallized atoms being ionized in a series, generating an electric effect. After hydro and wind power, solar energy is the third most widely used renewable energy according to the installed capacity.

BASIC CONCEPTS OF SOLAR TRACKING

A solar tracker is an electro mechanical device for orienting a solar photovoltaic panel toward the sun trackers, especially in solar cell applications require a high degree of accuracy to ensure that the concentrated sunlight is directed precisely to the powered deice. The direct beam of sunlight carries about 90% of solar energy, where as the diffused sunlight carries the remainder. It is necessary to present the maximum surface area of the photovoltaic module to the direct beam of sun, in order to produce the largest amount of power. This can be accomplished using solar tracking system which keeps on moving solar panel with the movement of sun.

In this implementation of solar tracking system, two sensors are used to detect the irradiance present at a particular point and time. One sensor is placed on east side and another on the west side respectively. The sensors are light dependent resistors with an arrangement to allow the light to be incident only one side: the east sensor, for example, is an light dependent resistor with a physical barrier for blocking the light coming from west side. The difference between their magnitudes are computed by the controller and it sends signals to the motor driver, thus stepper motor rotating the solar panel according to the fixed step angle. This is repeated until the difference between two sensor outputs falls below a predefined value.

REQUIRED COMPONENTS FOR THE PROPOSED SYSTEM

Development of solar panel tracking system has been ongoing for several years. As the sun moves across the sky during the day, it is advantageous to have the solar panels that track the location of sun, such that panels are always perpendicular with the position of sun. The major components that are used in the prototype are given below:-

- Photovoltaic panel
- Light dependent resistors
- Arduino Uno R3
- Motor driver IC-L298
- Stepper motor
- Bearings

Fig.1 represents Block Diagram of the proposed system.

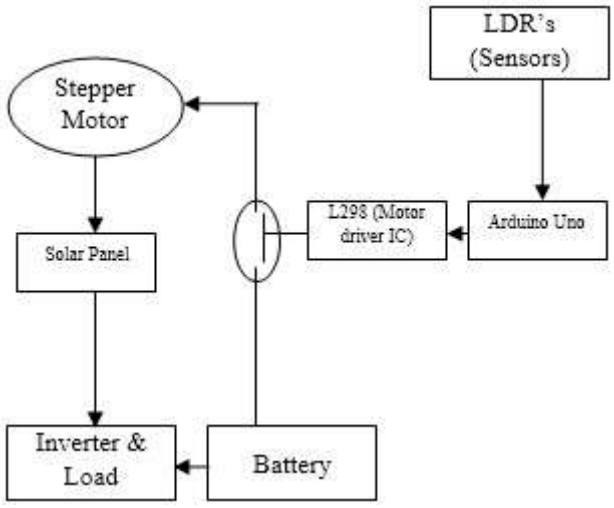

Fig. 1 : Block Diagram of proposed system

Photovoltaic panel

A photovoltaic panel is a packaged interconnected assembly of photovoltaic cells, also known as solar cells. A typical silicon photovoltaic cell is composed of a thin wafer consisting of an ultra thin layer of phosphorous doped (N-type) silicon on top of a thicker layer of a boron doped (P-type) silicon. Regardless of size, a typical silicon photovoltaic cell produces about 0.5-0.6V DC under open circuit and no-load conditions. The current and power output of a photovoltaic cell depends upon the efficiency and intensity of sun light striking the surface area of the cell. The majority of modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium terrulide or silicon. The solar panel used in the proposed system is 150W power rating

Light dependent resistor

A photoresistor or light-dependent resistor is a light controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity. In other words, it can be best described as light-dependent resistors exhibits photo conductivity. These are made up of high resistance semi conductor. In the dark, a photoresistor can have resistance as high as several megohms. While in light, photoresistor have resistance of few ohms. If the incident light on the photoresistor increases a certain frequency, then electrons which are bounded in the valency band moves to the conduction band by absorbing photons present in the light.

Arduino Uno R3

Arduino is a very popular and easy programmable board for creating new systems. It is a simple hardware platform and consists of free source code editor with an easy compile/upload feature. Arduino is also the most popular microcontroller board for advanced users and has been used to make robots, home automation gadgets, automotive projects, for sensing and controlling purposes, interactive objects like animated sculptures.

An Arduino board consists of an Atmel 8-bit microcontroller with complementary components that facilitate programming and incorporation in to other circuits. An important aspect of Arduino is its standard connectors which providers the users to connect various interchangeable add-on modules to CPU board known as shields. Fig.2 shows a typical Arduino board.

Fig.2: Arduino Board

Programming in the Arduino controller can be done using a procedural language which is more similar to C/C++ languages. The series of instructions can be written in terms of mathematical functions and can be converted in to executable format. User has feasibility to declare variables, functions, arrays and looping iterations.

Motor driver IC-L298

L298 is an integrated electronic circuit that enables a voltage to be applied across the load in either direction. It is a high voltage, high current dual full-bridge driver designed to accept standard transistor-transistor logic levels and drive inductive loads such as relays, solenoids, stepper motors. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing device. An additional supply input is provided so that the logic works at a lower voltage. In this methodology, L298 is used as an switch, which is controlled by using Arduino. Whenever there is a signal from the controller to rotate the stepper motor, L298 closes the circuit and the panel is rotated according to the fixed step angle. In the remaining time L298 remains in the breaking position of a switch. The pin diagram of motor driver IC-L298 is shown in the Fig.3.

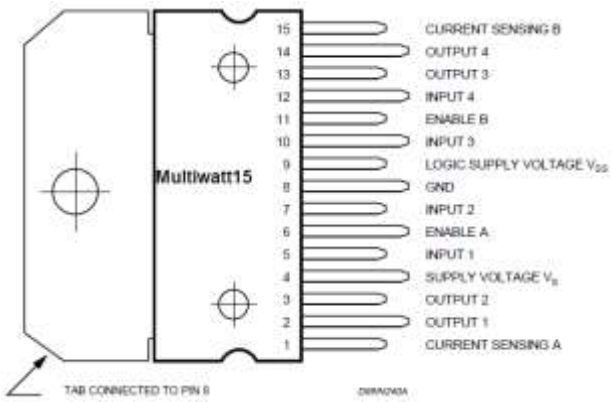

Fig.3: Pin Diagram of IC-L298

Stepper motor

To rotate the panel along the axes , solar tracker needs stepper motor. A stepper motor is a brushless DC electric motor that divides a full rotation in to a number of equal steps. The motor's position can be commanded to move and hold at one of these steps without any feedback sensor, as long as motor is carefully sized to a application. The stepper motor chosen for the proposed system is 12V helical worm geared stepper motor with step angle of 1.80 and output torque of 15N-m as shown in Fig.4. The main reason behind opting for geared motor is its low power consumption and also the torque produced is enough to rotate the photovoltaic panel.

Fig.4 : Stepper motor used for the proposed system

Bearings

A bearing is a machine element that constrains relative motion to only the desired motion and reduces friction between the moving parts. Bearings provide free linear movement of the moving part or for free rotation around a fixed axis. Bearings are classified according to the type of operation, the motions allowed.

IMPLEMENTATION

The installation of 150W solar panel involves the following procedure:

A one and half inch pipe of length 20 feet is taken and augmented in to 6,5 and 3.5 feet of length pipes. 5 feet and 3.5 feet pipes are used as vertical supports and 6 feet pipe is used as diagonal support. All these pipes are arranged and welded in such a manner that diagonal pipe forms an angle of 15 horizontally as shown in Fig.5.

Fig.5: Supporting Stand for the Photovoltaic Panel

The rotor was mounted onto the diagonal support using the bearings. A second piece of 0.75 inch pipe is placed in to the rotator and screwed. It is then attached to the bottom support by bolts. Brackets were used to secure the solar panel to support pipe. Holes are drilled through the bracket in to the centre of aluminum angle that was attached to the solar panel and solar panel is attached to rotator pipe using bolts as shown in Fig.6.

Fig.6 : Installation set up of proposed system

The panel is fixed on to the 0.75 inch pipe along with the helical worm geared stepper motor shaft connected to it. The panel will rotate according to the command signals given by Arduino controller. .

CONTROL ALGORITHM AND PRELIMINARY RESULTS

Control algorithm

In order to demonstrate the efficiency of the proposed system, a control algorithm is generated as shown TABLE 1.

TABLE 1. CONTROL ALGORITHM

Step#	Action
1	Install the solar panel
2	Keep the solar panel in initial position
3	Find the maximum sunlight using photo resistor and save the position of solar panel
4	Measure the current
5	If current is less than threshold value, wait for 30 min and go to step3 otherwise go to step6
6	Turn the panel towards left for provided step angle and measure the current. If the current is greater than previous current, continue turning left until the maximum current in x and y axes
7	Send the coordinates (x,y) of the solar panel to the controller
8	Go to step3

Fig. 8 represents flow chart of Control Algorithm used in the proposed system.

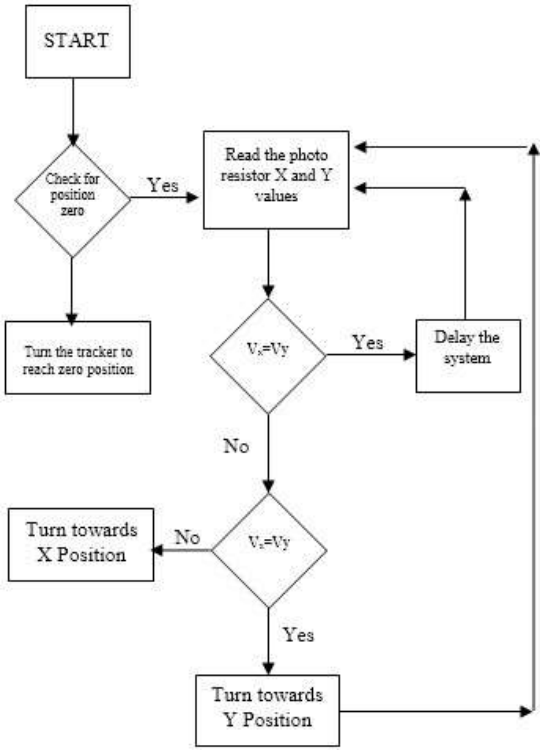

Fig. 8 : Flowchart of Control Algorithm

Preliminary results

In order to assess the efficiency of the proposed system, some measurements were taken during a sunny day. TABLE II shows the comparison between the maximum current using a fixed photovoltaic panel and using the proposed system at different times.

TABLE II. COMPARISION BETWEEN THE CURRENT USING FIXED PANEL AND USING PROPOSED SYSTEM

Time	Current using a fixed solar panel (mA)	Current using the proposed system (mA)
08:00 AM	52.50	106.25
09:00 AM	68.75	112.50
10:00 AM	93.75	115.00
11:00 AM	101.25	118.75
12:00 PM	115.00	123.75
01:00 PM	118.75	123.75
02:00 PM	110.00	123.75
03:00 PM	95.00	122.55
04:00 PM	52.50	118.75
05:00 PM	28.75	118.75
06:00 PM	10.00	90.00
Total	846.25	1274.00

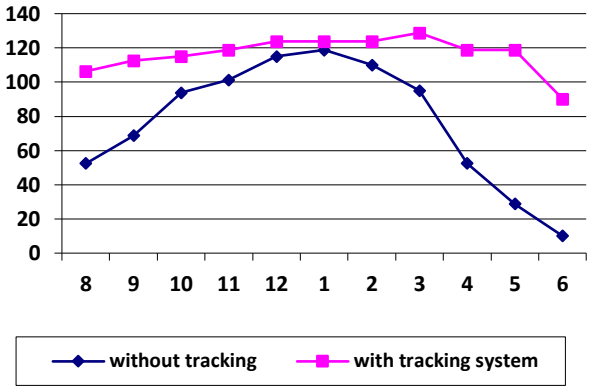

Fig. 9 : Output current of the proposed system

The fig. 9 shows the efficiency of the tracking system. It seems that the output of solar panel is increased by 64% on a sunny day. In addition, the proposed system consumes little power to turn the photovoltaic panel using stepper motor. This system can power itself from the photovoltaic panel using a battery.

CONCLUSION

This project reports a 'Arduino based improved solar tracking system'. The monitoring controller based on closed loop algorithm is designed and implemented for the proposed system. Thus solar tracking system is an efficient and feasible means of obtaining optimal solar energy from the sun by constantly aligning the photovoltaic panel along the direction of sun. The programming used for Arduino can be modified for future requirements. The proposed methodology of solar tracking system can be used for normal and bad-weather conditions. For maximizing the output further, maximum power point tracking can be used along with solar position tracking.

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