

Design and development of reliable Solar Tracking System with Rotation and Tiltation of solar panel

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Abstract - The important factor that helps in the development of any country is how much energy is being produced and at what rate it is being consumed. The energy that is being harvested from sun rays is clean energy and to total up maximal solar radiation onto the solar panel, solar tracking system plays a vital role. The intensity of radiation provided by the sun rays that reaches the earth in an hour has more intensity and energy as compared to the energy consumed by the people of the world in a year. Sunlight being a cause of energy can be absorbed by solar panel but they should be designed and developed with proper solar tracking system. The importance of sun tracking system arises due to the fact that for obtaining enormous quantity of solar energy it is required that the sun rays should fall perpendicularly on solar panel throughout the day. Basically sun tracking system tracking system is a mixture of electronics, electrical and mechanical part that give support to the solar panel so that it can follow the position of sun rays. The suggested sun tracking system makes the rotation but along with rotation the solar panel will tilt with the help of stepper motor, LDR and arduino. The tiltation of solar panel along with the rotation will keep the solar panel facing the sun rays perpendicularly which will lead to maximum extraction of solar energy throughout the day

Key Words: PV panel, Arduino, LDR, Stepper motor, Sun tracking system, Mechanical damper

1. INTRODUCTION

Today the utmost issue regarding the progress of human kind is the energy produced and energy consumed. In this 21st century the whole world is facing the problem of clean energy that could meet the quantity of a commodity or a service that people are willing or able to buy at certain price. It is expected that the sun will become the main electricity production source by 2100 according to the study presented by the German Council on Climate Change [1]. Solar cell or photovoltaic cell is an electrical device that converts the energy from the sunlight directly into electricity by the photovoltaic effect which is a physical and chemical phenomena. Solar cells are the building block of PV module [2]. Basically solar panel is constructed with the help of solar cells which are organized in a group and these solar cells use certain wavelength of visible light to make electricity. Another name for solar cell is photoelectric cell because the function of solar cell is to convert the light energy into required electricity energy. The essential considerations that

decides the overall efficiency of solar panel is to use a solar tracking system, maximizing the power output and increasing the efficiency of solar cells. Since the position of the sun changes continuously throughout the day and the intensity of sun rays is not uniform on PV module, so for getting more sun rays on solar panel solar tracker plays a much important role[3]. The rays from the sun should fall perpendicular onto the solar panel to maximize the capture of sun rays and this is done by pointing the solar panel towards the sun and following its path across the sky [3]. In fact previous researches showed that about 20%-50% more solar energy can be captured depending upon the geographic location by adding a sun tracker to a PV system [4]. Sun Tracking system is a considerable method that is being accessed in order to harvest maximum solar energy from PV Module in comparison to fixed solar panels. The two most significant categories of tracking system are fixed tracking system and movable tracking system. A tracker rotating in the east-west direction is known as single axis tracker. A single axis tracker has one degree of freedom that act as axis of rotation [3]. A tracker that counts for daily and seasonal motion is known as Dual axis solar tracker and it has two degree of freedom that act as axes of rotation. DAT allows for optimum solar energy level due to their ability to follow the sun vertically and horizontally [3]. The awareness about the sun tracking system is rising but the complication is that people does not know the application and disadvantage of the system completely. Solar panel are a form of active solar power a term that describes how solar panel make use of sun's energy , solar panel harvest sunlight and actively convert it into electricity[5]. Tracking of sun rays when the sun rays fall in the morning till the rays is dawn in the evening can hike the performance of solar panel to generate electricity. To what extent solar radiation is being captured by the PV Module for whole day is built upon two aspects i.e. rotation and tilt angle. The tilt angle of solar panel is important for capturing solar radiation and it depends on the path of the sun in the location of solar panel [6]. A particular aspect which is necessary for maximum extraction of solar energy is that the sun rays should fall perpendicular onto the solar panel and this is done by placing the solar panel close to the location of sun rays. The procedure to enlarge the capability of sun tracking system is that rays from sun should incident perpendicularly on solar panel when it is rotating and tilting. In this paper a model has been described such that the solar panel will rotate by following the principle of duplex support sun tracking system. But the attending PV Module will rotate but along with rotation it

will tilt itself according to the changing position of sun rays. Due to the tiltation in solar panel the sun rays will fall perpendicular to solar panel which will eliminate the problem of shading on solar panel.

2. Design and Working

The Design and working of proposed solar tracking system has been divided into six categories:-

- (2.1) Block Diagram
- (2.2) Electronics Part
- (2.3) Electrical Part
- (2.4) Mechanical Part
- (2.5) Programming
- (2.6) Working

2.1 BLOCK DIAGRAM

The relationship between the different blocks of the commenced solar tracking system has been shown diagrammatically in below figure 1.

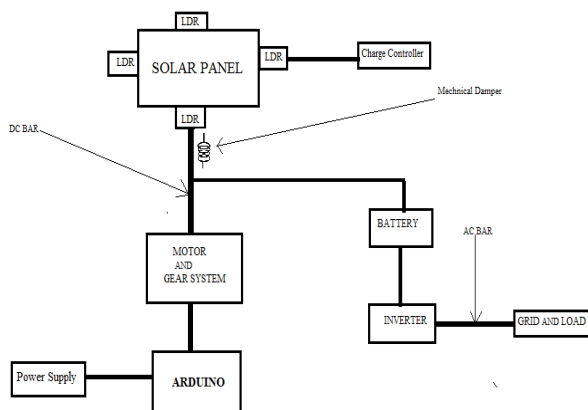


Fig -1 Block diagram of Solar Tracking System.

2.2 ELECTRONICS PART

Generally Arduino and LDR come under the electronics part of the proposed solar tracking system. Arduino is an open source microcontroller which can be easily programmed at any instant of time. Arduino platform was designed for hobbyists, students and professional to create devices that interact with their environment using sensor [7]. Arduino can be treated as a fundamental character because it can be computed as per the requirement and is convenient to interface it with the stepper motor. LDR are the backbone of whole tracking system because the working of all other components whether it is rotation of PV module, Arduino or stepper motor are dependent on LDR. To track the change in the progress of sun rays for whole day the commenced sun tracking system usage four LDR. LDR are used to sense the

intensity of sunlight and hence the sun's position in the sky. LDR has the property of reducing its resistance as the light falling on it increases Keeping this principle in mind a microcontroller program is written for this purpose [8]. It is the LDR that as a sensor compares the intensity of the sun rays falling on them and help the solar panel to track the sun rays with the help of Arduino. LDR is attractive in many electronic circuit designing because of its low cost, simple structure and ragged features [9].

2.3 Mechanical Part

The crucial component of commenced sun tracking system is the mechanical part because it is the hardware involving gear system that helps to rotate the solar panel as per the requirement. Since solar panel is being placed on this part so it is required that this part should be firm to grip the weight and rotation of solar panel Two stepper motor with gear system and a mechanical damper are adjusted below the solar panel. Motor adjusted with gear system helps the solar panel to spin its position according to the changing position of sun rays throughout the day. Adjustment regarding the components of sun tracking system can be made so that Arduino can be interfaced with stepper motor and this will help the solar panel to rotate or spin. A mechanical damper is a device that deadens, restrain [10]. When stepper motor rotates the solar panel a mechanical damper in combination with motors can tilt the solar panel as per the programming done in Arduino. Hence slight change in sun rays then slight change in rotation of solar panel along with tiltation controlled by arduino interfaced with stepper motor. Below figure shows the rotation as well as tiltation of solar panel according to the changing position of sun rays.

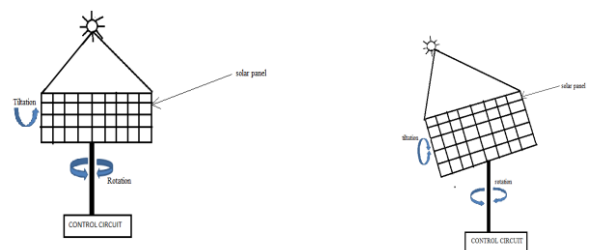


Fig2:- Solar panel rotation along with tiltation

Above figure depicts that tiltation of solar panel along with rotation will keep the sun rays falling perpendicular onto the solar panel which in turn will increase the overall efficiency of solar tracking system.

1.6 ELECTRICAL PART

The electrical part of the commenced sun tracking system describes the working of solar panel, role of stepper motor and requirement of battery or inverter. This part shows that how much output the system will produce and the output provided will decide the comprehensive performance of sun tracking system. The essential operation of PV module is to

gather the sun rays and convert them into electricity. The amount of electricity formed handy by PV Module is calculated on the basis of radiation from sun rays falling on solar panel. Solar panel efficiency can only be improved by using solar tracker with panel continuously tracking the sunlight throughout the day to get maximum solar energy [11]. The proposed solar tracker uses two stepper motor and these motor will spin the solar panel according to the magnitude of sun rays falling on LDR. The profitable operation of stepper motor is that being an electromagnetic device it converts digital pulses onto mechanical shaft rotation.[2] Stepper motor can provide number of desired result such as simplicity, low cost, high reliability and high accuracy of motion[2]. The requirement for PV module is that the energy produced by it in the form of electricity has to be stored in batteries during the sunshine hours. Batteries are used to accumulate solar energy being generated by PV Module and stores this energy that can be used during night hours[10]. A solar inverter or PV inverter converts the variable DC output of a PV module into a utility frequency AC that can be fed into commercial electrical grid or use by local off-grid electrical network. The compatibility of inverter for PV system is mainly decided by two factors that is use of batteries and site location[2].

1.7 PROGRAMMING

Mainly the functioning of dual angle tracker depends on the commutation done by the Arduino. The ultimate advantage provided through Arduino is that it can be programmed according to the requirement of the system. There are many function present in the software of Arduino which makes its coding so easy and fast. Implementation of program as per requirement is not a complex procedure and it does not require any extra codes[14].

1.8 WORKING

Below figure shows the arrangement of components used in commenced sun tracking system.

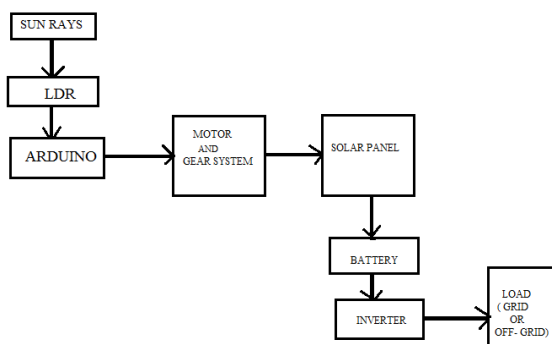


Fig3:- Block diagram of STS

The working of proposed solar tracking system depends upon the LDR because LDR is an electronic device which

has the characteristic of showing increase and decrease in its resistance on the behalf of radiation fall on LDR. The proposed sun tracking system needs four LDR which are placed on the four side of PV Module and these LDR work in pairs. LDR as a sensor senses the intensity of sun rays fall on them and comparing the brightest part it send signal to the Arduino. On the behalf of input from LDR arduino controls the rotation of the panel with the help of stepper motor using gear system. The programming of Arduino is done such that on receiving the signal from LDR it will command the motor to spin the solar panel in the direction of sun rays. Below the solar panel the arrangement of stepper motor and damper can be placed such that motor will rotate the panel while the damper will tilt the solar panel. The basic requirement of the tiltation angle will be needed during the morning and evening hour as during the mid day the flat arrangement of solar panel will do the work. In short LDR as a sensor compares the intensity of sun rays falling on them and give this signal to the Arduino. The data from the LDR is collected by the Arduino and then it process this data, after processing the data Arduino commands the stepper motor to rotate the panel according to the changing position of sun rays. Damper tilts the panel after rotation such that the solar panel can capture maximum sun rays throughout the day. The output from the solar panel as DC is given to the battery the requirement of PV panel is that the energy produced by it is electrical energy which has to be stored in battery during the sunshine hours. Batteries store the electricity from solar panel and fed this electricity to the inverter. The inverter that is employed in sun tracking system converts the DC output received from battery into AC input and this AC input can be used by local off grid or can be fed to commercial electrical grid.

2. ANALYSIS

2.1 Analysis of Tilt Angle

To acquire maximum radiation of sun rays on solar panel, then they should be mounted with accurate tilt angle. In order to have maximised annual average incident solar energy on the surface of PV system, it is required to determine optimal tilt angle. Optimization of tilt angle ensures the maximum energy generation there by reducing the cost of power generation [12]. When the direction of PV module is perpendicular to the direction of sun rays then only it will extract maximal solar energy from the solar panel. Manual adjustment of optimal tilt angle of solar panel for a limited number of times during a year result in more total power generation over a year [6]. The inclination we apply to the solar panel helps us obtain a higher efficiency in energy absorption and the optimum degree of inclination depends on every geographical location. In contemporary years various arrangements have been refined to resolve about the appropriate slant for PV Module. Below Table1 shows the method that how to figure out the correct angle for solar panel that can help to extract maximum solar energy.

SEASON	ANGLE/ CALCULATION	TILT
Summer	(Latitude*0.9)+ 29°	
Spring & Fall	(Latitude*0.9)-23.5°	
Winter	Latitude-2.5°	

For maximum output from the PV system it is necessary to understand the nature of dependence of solar radiation and inclination angle of PV system [12]. Another easy method to get solar angle is the solar panel calculator. The optimum angle varies throughout the year depending on the season and your location, this calculator shows the difference in sun height on a month-by-month basis [13]. Literature review about the tilt angle determines that PV module can regulate to rotate and tilt at such an angle which will extract maximum amount of energy

2.2 Analysis of Output

The amount of electricity that is being formed handy by the PV module mainly comes under three considerations that is efficiency of solar cell, esteemed size of PV Module & the amount of solar radiation falling on solar panel throughout the day. Most of the solar panel available in the market today can provide output power in different ranges such as 250watt24V, 10watt12V and 60watt12V. The electricity produced by the solar panel is to be stored in batteries. A 12V battery can be used by the cell phones, cooler, spotlights and fans. The output from the inverter such as 220V or 115V can be used by laptops, water pumps, television etc. The overall electricity produced by commenced sun tracking system can be utilized by various departments surrounding us such as school, colleges, universities, government building, household purposes and many more.

3. CONCLUSION

This commenced research is about the design and development regarding the tracking of sun rays for maximum extraction of solar energy. LDR are considered to be the backbone of the system because the overall working of sun tracking system depends upon the amount of radiation falling on solar panel that is being sensed by LDR. Arduino plays the vital role of controller as it controls the rotation and tiltation of PV module with the help of stepper motor and mechanical damper. The rotation and tiltation of the solar panel tracks the movement of sun rays throughout the day which increase the efficiency and production of STS. Advantage of proposed system is that components used are less that can be fitted into small packages, arrangement of component is easy and this results that it is less expensive solar tracking system.

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