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Research Article

Enhanced performance of Automatic Single-axis Solar Tracking system fed Induction Motor Drive

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Abstract — Nowadays Nonconventional Energy sources got vital Role to meet the increase in energy demand because of depletion of fossil fuels. This paper is to design and construct a solar tracker system increases the electricity generation that follows the Sun direction because the continuous movement of the sun limits maximum sun light irradiation absorption. The proposed system is simple and low-cost price solar tracker system with single axis. A single axis tracker can increase production between 25% to 35%. The proposed system develops with PIC microcontroller, LDR's are used to detect the Sun direction. The operation of the experimental model of the device is to drive Induction motor intelligently controlled by a dedicated drive unit that moves a PV panel according to the signals received from two simple but efficient light sensors. It runs a single-phase induction motor through an Inverter circuit. The main aim of this paper is that it compares the power produced with and without solar tracker at some maximum point in different temperature conditions.

Keywords — Microcontroller, Solar tracker, Light Detection Resistor, light sensors

1. Introduction

Whatever man lives and operates, electricity plays a major part. A nation's survival and stability are significantly related from the rise in electricity use. Owing to industrial development, and rise and widespread usage of electric machines, the Energy demand of the world is growing continuously. The global energy study states that we get about 80% of our electricity from traditional fossil fuels including oil (36%), gas (21%) and coal (23%). It is well known that the period does not arrive to full depletion in all these outlets. Alternative methods can also be considered in the immediate term to combat the oil shortage. Solar energy is the perfect choice. The energy generated by utilizing the influence of the solar rays is solar power. It is the cleanest electricity source and can least pollute the atmosphere.

A solar panel is a wide flat rectangular about the size of a radiator and a roof, composed of several solar collectors known as solar panels protected by a glass sheet shield. Cells are typically octagonal and marked, bluish black, and are around the size of an adult's hand. The cells in a solar panel are built to generate electricity like the cells in a battery except while a battery cell absorbs chemical fuel, the solar panel cells generate electricity by absorbing sunlight. Often, they are called PV cells.

The production capacity of the solar panels is optimum, since the sun's lighting field and the strength of the solar rays is highest, as they are aligned perpendicularly to the directions of the sun rays. The constant adjustment in the relative angle of the sun to the ground lowers the solar panel watts. The easiest approach to improve the efficacy of the photovoltaic panel is by solar photo-tracking device. The scheme contains direct solar panels or modules to the light. trackers. These machines adjust their concentration throughout the day to suit the direction of the sun to optimize capture of electricity. Trackers decrease the incidence angle between the entrant light and the panel in photovoltaic systems and increase the amount of energy generated by the device. Concentrated solar and solar thermal have lenses that receive sunlight directly, meaning the solar trackers must be carefully positioned through the set of electricity. Both concentrating solar systems have trackers since they cannot create electricity until they are properly guided to the sun. The paper consists of a limited number of LDR sensors and a motorized system to move the screen towards the light. If the sun pushes the solar cell plate, solar energy produced by the solar cell may be increased. Test the sunlight sensor and monitor the motorized system using a microcontroller. This machine runs constantly without a pause. This device relies on the condition of the relay switch, and powers the engine directly by means of solar power or energy contained in the tank. An embedded machine is a software and hardware mixture to execute a operation. Microprocessors and microcontrollers are some of the major equipment used in embedded items.

Sakshi Mishra et al [1], discussed an application oriented photovoltaic power generation system along with a control mechanism which assists in extraction of increased power at normal mode of operation which includes constant frequency inverter operation. They developed a dynamic model of a solar fed Induction motor drive in SIMULINK by using MPPT technique to trap maximum power which increases the solar efficiency. They concluded that the dynamicity of the developed model offers the user to change the parameters of every components and environment to fit their purpose. Vikas V. Kulkarni et.al [2] developed a SIMULINK model and Hardware of a solar powered battery charger and Induction motor using MPPT method. They introduced microcontroller-based control circuit to improve the efficiency. The developed system is simple, easy to maintain and a feasible method of maximizing the light energy received from sun. The developed software for this work can be used outside the mechanical part, thus it is flexible for future modification. The experimental results are validated, found that similar behavior in efficiency and the current output when compared them with the simulation results. Mehmet Duranay et al [3] In this paper discussion done on importance of solar energy & explained the effect ofreflected radiation on PV panel.
They carried out theanalyses in both direct solar radiation and double intensity rays reflected from mirro rs were obtained due to mirrors. A detailed efficiency analysis was also made for both the cases with theoretically and experimentally the calculated efficiency values are compared. They conclude that the amount of radiation affecting panels was at the highest levels at noon, the panel efficiency was at its lowest levels at noon. The negative effects of double intensityeon the panel were also determined. Jaya Prakash S T et al. [4] explained the important of renewable energy resources and explained about the Automatic microcontroller based Solar tracking system. They designed and implemented a solar tracking system which detects the position of the sun and makes the panel to contact with the sunlight perpendicularly. To provide maximum power output, solar panel must face the sun directly. Pavan Badarinath [5] discussed about different types of solar trackers and how to find out the suitable system which will perfect fit for particular job site. They designed and fabricated a prototype solar tracking system with light dependent resistors (LDR's) to detect the sunlight. A control circuit was designed with micro controller and programmed to detect sunlight via the LDR's for actuating the servo to position the solar panel. They conclude that solar tracking system are slightly expensive than their stationary solar system, due to their more complex technology and moving parts necessary for their operation. Tudorache, T et.,al[6] explained the single axis solar tracker device ensures the optimization of the conversion of solar energy into electricity by properly orienting the PV panel in accordance with the real position of the sun. Sumant Malav and Shelly Vadhera [7] discussed with the control algorithm for solar tracker can move the panel in both the directions i.e. east to west and west to east in a step function. The stepper motor is switched on at regular intervals of half an hour owing to which there is reduction in consumption of power as compared to that of a continuously run motor in conventional solar tracking systems for a single axis solar tracking system. Ravi Tejwani et,.al [8] describes the implementation and working of 360o sun tracking system with automatic cleaning. In this mechanism, the solar panels make a rotation of 360o in a day, which results in sliding of
cleaning brushes twice over the PV modules. In terms of daily energy generation, the presented tracking -cum cleaning scheme provides about 30% more
energy output as compared to the flat PV module and about 15% more energy output as compared to PV module with single axis tracking. Dr. Manal H. Jassim et,.al [11] explained tracking system makes the solar photovoltaic panels perpendicularly facing the sun and therefore more solar energy extracted and so the efficiency of the solar photovoltaic panels increased. Soumya Das et,.al [12] to develop a microcontroller-based solar panel tracking system which will keep the solar panels aligned with the Sun in order to maximize in harvesting solar power.

It is widely understood that microprocessors are processors with general targets since they recognize, process, and distribute the inputs. By comparison, a microcontroller embraces the data as inputs and manipulates them, interfaces the data with multiple machines, monitors the data and thus eventually produces the output.

2. Use of solar tracker

Solar tracker plays a major role in the whole project. It enables to get maximum efficiency using tracker. As we know that sun rises in the East and sets in West. In this way, the panels can rotate only to follow the Sun at its altitude angle, correcting the position of the panels every day due to the Sun's declination. With solar tracking technology, the annual solar irradiation intensity of regions with average solar resources can be improved from 1200 kWh/m^2 to 1500 kWh/m^2. It is very hard to tilt the panel according to sun direction. So, with the help of Light Detection Resistor automatic orientation of the panel is possible. Here we used two LDR’s front and back. We used front LDR for sensing the light and gives signal to the DC motor to move forward direction and when light falls on second LDR then orientation of the panel stops i.e., gives the signal to motor to stop at that point.

Tracking systems offer greater levels of energy output compared to fixed solar arrays because they can follow the sun's movements. With the use of the solar tracker the problem of fixed panel which captures low energy at some temperature can be made resolved. With the implementation at any environmental conditions, we can get maximized output even at low temperature and humidity. A tracker which rotates from east to west only is known as single axis solar tracker. There are many applications of solar trackers. They are heating, hybrid power plants, solar vehicles, automation, solar lamps, streetlights etc.

Calculation of torque required for the rotation

Moment of inertia of a rectangular body,

$I=M(a^2+b^2)/12$ in Kgm^{-2}

where

α is angular acceleration and w is angular speed.

I = moment of inertia.

$$\alpha = \nabla\omega / t$$

where, $\nabla\omega = \omega_1 - \omega_o$ and

ω_o = initial angular velocity

ω_1 = final angular velocity

$T = I \times \alpha$ in Nm

3. Block diagram

The solar tracker rotating motor system structure diagram consists of a solar panel, two LDR's, PIC16F72 Microcontroller, L293D DC Motor driver circuit, Single phase Induction motor, MOSFET Inverter, step down transformer, step up transformer and a battery. The main aim of the block diagram represents how the solar energy is stored in a battery and the working of a solar tracker based on a program dumped into the microcontroller using PIC KIT2 software platform.

First, the voltage from main switch is step down to 12V using a 230/12V step down transformer. Then from a bridge rectifier 12V AC is converted into 12V pulsating DC which is again given to a 1000mf, 25V capacitor to remove all the disturbances from bridge rectifier output and through a unidirectional diode it is supplied to a dry acid rechargeable battery whose capacity is 12V, 3A

Battery is supplied from the two sources one is from the stored energy of solar panel and the other is from a regulated power supply. Firstly, when sunlight falls on the first LDR it gives the signal to microcontroller. Microcontroller gives signal to motor driver circuit to move forward. Hence solar panel rotates until sunlight falls on second LDR. For effective operation of the microcontroller, we need 5V dc supply which is supplied from the 7805 regulators.

When LDR senses light it converts analog to digital gives signal to DC motor driver to rotate the DC motor. When the intensity of the light falling on right LDR is more, panel slowly moves towards right and if intensity on the left LDR is more, panel slowly moves towards left. In the noon time, Sun is ahead and intensity of light on both the panels is same. In such cases, panel is constant and there is no rotation. Through an inverter 12V DC is converted into 12V AC. Using a step-up transformer 12V AC is converted to 230V AC for running a single-phase induction motor.

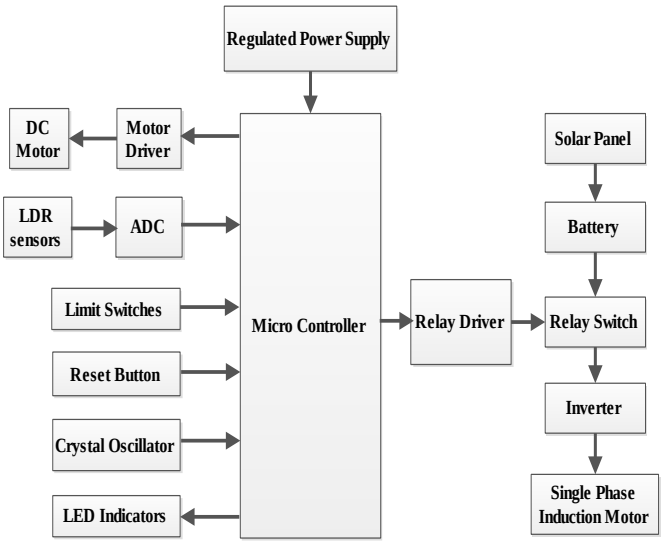

Fig 1: Block Diagram

4. Hardware design

The main components which are used for the solar tracker to rotate are as follows:

A. Microcontroller

Microcontroller is heart of the system. In this PIC16F72 microcontroller is used which has many features such as ADC, USART, Timers, Memory. We used this because the interfacing of LDR and Crystal Oscillator is very smooth and effective. It has 28 pins. PIC stands for a Microchip Technology Peripheral Device Controller that recognizes the microcontrollers on a single chip. The 8-bit microcontrollers were really popular.

B. Solar Panel

A solarpanel, or photo voltaic (PV) module, is anassembly of photovoltaic cells mounted in a framework for installation.Solar panels use sunlight as a source of energy andgenerate direct current ele ctricity. It is main equipment for storing energy to a battery. We used a normal 12V, 5W capacity solar panel which has 18 cells connected in series. Each cell capacity is 0.66V and it has 21V open circuit voltage. Maybe its negligible environmental effect reflects the main benefit of solar energy development.

It does not need water to cool the device, such that no major heat mismatch is produced. It has short circuit current of 0.32A.

C. Batteries

Li-ion battery is a type of rechargeable battery. In this battery, lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Lithium-ion is a low maintenance battery, High energy density and Relatively low self-discharge.

D. Resistor where Light is Dependent

It is a variable resistor whose value drop on the surface of the LDR from a rise in light intensity. As a light-dependent resistor, it is expanded. An LDR consists of a high-resistance cadmium-sulphide semi-conductor. When there is a sufficiently high frequency light on the chip, the photons that the semiconductor absorbs give small electrons enough energy to join the conductive band. The free electrons that result conduct electricity minimize resistance.

E. Transformer

In this project we used a step-down transformer for lowering voltage to 12V AC for converting it to 12V DC supply using a bridge rectifier and a filter. To supply to the single-phase induction motor, we used an inverter for converting again to 12V AC which is again stepped up to 230V AC supply for giving to induction motor.

F. Rectifier

In this circuit we used four resistors which are connected in bridge form to convert 12V AC supply to pulsating dc. This 12V pulsating DC is given to capacitor to remove all the disturbances and pulses to convert it to a pure dc signal.

G. Inverter

A simple MOSFET inverter is used to convertDC into AC supply. Two MOSFETS are connect ed in parallel combination to supply for more load. CD4047IC gives 50
60Hz square wave pulses to MOSFETS.

H. Induction Motor

Single phase motors are simple in construction, reliable, easy to repair and comparatively cheaper in cost and therefore, find wide use in fans, refrigerators, vacuum cleaners, washing machines, other kitchen e quipment, tools, blowers, Air cooler submersible pump, small farming appliances etc.

5. Final prototype

The figure of Automatic solar tracker induction motor drive systems is shown below.

Fig 2: Automatic Solar tracker induction motor drive

6. Analysis

we compared the results of power generated with and without solar tracker.

Case I: The power generated with solar tracker.

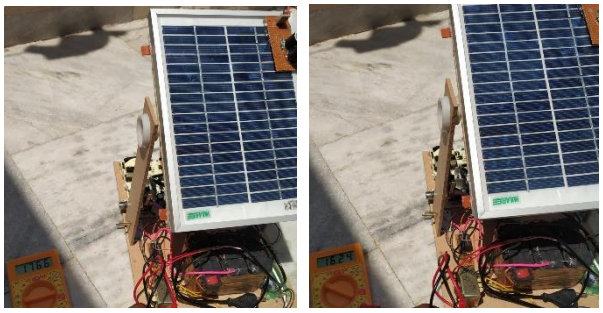

Fig 3: Testing with solar tracker

The readings for the current and voltage with solar tracker on 10th April at 11:00 AM to 2PM is tested and the readings are tabulated in Table 1

Table 1: Reading with solar tracker

Date	Time	Temp	I(mA)	V(volts)	Power

10/4/2021	11AM	34	198.4	12	2.4W
10/4/2021	12PM	36	169.8	15	2.6W
10/4/2021	1 PM	37	176.6	16.24	2.9W
10/4/2021	2 PM	39	230	16.5	3.8W

CASE II: Power generated without solar tracker.

we performed the same experiment at some angle without using Solar tracker for the same day and same time. The figure .4 reparents the photo snaps without using solar tracker. The test results are tabulated in Table.2

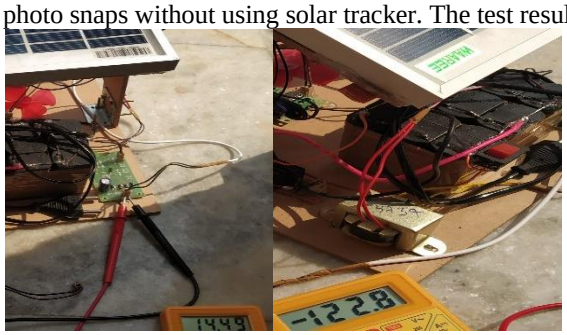

Fig 4: Testing without solar tracker

Table 2: Reading without solar tracker

Date	Time	Temp	I(mA)	V(volts)	Power
10/4/2021	11AM	34	114	12	1.5W
10/4/2021	12 PM	36	120	13	1.6W
10/4/2021	1PM	37	122.2	14.5	1.8W
10/4/2021	2 PM	39	170	16	2.7W

The tracked solar system has improved the efficiency of solar panel. It is mathematical expressed as:

% Efficiency= (Ptracked-Pstationary)/ Ptracked ×100

% Efficiency= (2.9-1.8)/ 2.9 ×100=28.94%

7. Conclusion

The designed solar system tracking in the direction of the sun during the day capture even more solar energy and therefore produce a considerably higher production capacity. The designed control circuit with a microcontroller, LDRS and a DC motor. This solar tracking device monitor the movement of the sun, to provide maximum power output. With the result analysis we can say that the power generated with solar tracker is maximum than without solar tracker at same temperature conditions at a time. It can be seen that on 10th April, 1:00 pm the power generated is 2.9W with solar tracker and 1.8W without solar tracker. Hence, we can conclude that maximum power is produced with solar tracker. Single axis solar tracking algorithm improved the power generated by the solar panel with an efficiency improvement of 28.94 %. In addition, the solar panel faces the ground throughout the night, in turn shielding it from dust particles and the its long existence. We also plan to improve this tracker 's independence in the future.

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