International Journal of Electrical Electronics & Computer Science Engineering
Volume 6, Issue 2 (April, 2019) | E-ISSN : 2348-2273 | P-ISSN : 2454-1222
Available Online at www.ijeecse.com

Maximum Power Point Tracking of Solar Panel using Microcontroller

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Abstract*: Sustainable advancements are the only alternative we are left with; with global warming increasing alarmingly and resources which are exhaustible in nature facing depletion, sustainable energy will remain as the main source of power in near future. Solar Trackers are devices which automatically orient in the direction of high intensity sunlight to effectively harness maximum solar power. In this paper, we have discussed design of an Automatic Solar Tracker using a solar panel, light-dependent resistor (LDR) and DC Motors based on Microcontroller 8051 platform. When the sun moves, the LDR sensor senses a reduction in light intensity forcing the DC Motors to adjust solar panel accordingly in the direction of high intensity. As dust gets collected on the panel throughout the day and reduces the efficiency of the panel, a cleaning mechanism has also been proposed.

Keywords: Solar Tracker, LDR, DC Motor, Microcontroller, Cleaning Mechanism.

I. INTRODUCTION

While a majority of the world's current electricity supply is generated from fossil fuels such as coal, oil and natural gas, these traditional energy sources face a number of challenges including rising prices, security concerns over dependence on imports from a limited number of countries which have significant fossil fuel supplies, and growing environmental concerns over the climate change risks associated with power generation using fossil fuels. As a result of these and other challenges facing traditional energy sources, governments, businesses and consumers are increasingly supporting the development of alternative energy sources and new technologies for electricity generation. Renewable energy sources such as solar, biomass, geothermal, hydroelectric and wind power generation have emerged as potential alternatives which address some of these concerns. As opposed to fossil fuels, which draw on finite resources that may eventually become too expensive to retrieve, renewable energy sources are generally unlimited in availability. Solar power generation has emerged as one of the most rapidly growing renewable sources of electricity.

Solar panel directly converts solar radiation into electrical energy. Solar panel is mainly made from semi conductor material. Si used as the major component for solar panels, which is maximum 24.5% efficient. Unless high 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[1].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 globe in recent days to harness solar energy in most efficient way.

In this paper the design methodology of a microcontroller based simple and easily programmed automatic solar tracker with its consequent cleaning mechanism is presented. A prototype of automatic solar tracker ensures practicability of this design methodology.

As part of literature survey the following papers were referred:

Syed Arsalan's, "Sun Tracking System with Microcontroller 8051" deals with the research and development of a Sun tracking system. [2]

Prof. Pooja K. Chattwani and Prof. Jayashree S. Somani's, "Intelligent Solar Tracker System Implemented On 8051 Microcontroller", this report deals with utilization of the maximum power from the sun. [3]

Weidong Xiao, Ammar Elnosh, Vinod Khadkikar and Hatem Zeineldin's, "Overview of Maximum Power Point Tracking Technologies for Photovoltaic Power Systems", can be used as a reference for future research related to optimizing the solar power generation. [4]

II. PHOTOVOLTAIC TECHNOLOGY

Photovoltaic (PV) materials and devices convert sunlight into electrical energy. A single PV device is known as a cell. An individual PV cell is usually small, typically producing about 1 or 2 watts of power. To boost the power output of PV cells, they are connected together in chains to form larger units known as modules or panels. Modules can be used individually, or several can be connected to form arrays. One or more arrays are then connected to the electrical grid as part of a complete PV system. Because of this modular structure, PV systems can be built to meet almost any electric power need, small or large [5].

The output power of a photovoltaic cell depends on the amount of light projected on the cell. Time of the day, season, panel position and orientation of the panel are also the factors behind the output power. The current-voltage and power-voltage characteristics of a photovoltaic cell are shown in Fig. 1.

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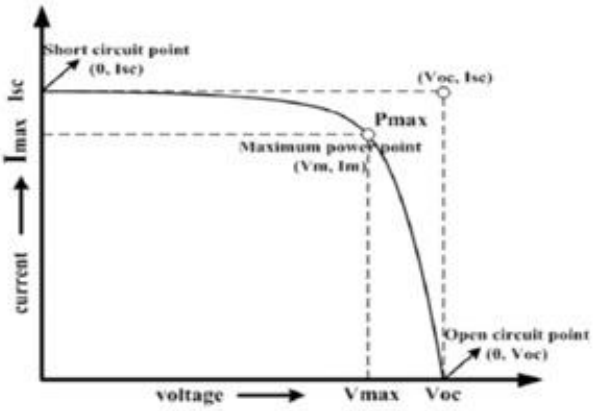

Fig. 1. I-V Characteristics of Photovoltaic Cell

III. PROTOTYPE OF AUTOMATIC SOLAR TRACKER

Development of solar panel tracking system has been ongoing for several years now. As the sun moves around the sky during the day, it is preferable to have the solar panels that track the location of the sun, such that they are always at right angles with the position of the sun. Available solar trackers in the market are costly to integrate with solar panel system [6]. In the developing countries where cost is one of the major issues to integrate technologies, solar tracking prototype presented in this paper can provide an effective solution as well as government these days provide subsidies[7]. The major components used in the prototype are given below:-

- Light Dependent Resistor
- Microcontroller
- DC geared motor

1. Light Dependent Resistor:

LDR's also known as photo resistors are devices that changes the resistance according to the intensity of incident ray illuminated on it. As the sun moves around and the intensity of the light incident on the sensor changes, the resistance and the voltage of LDR changes. The output voltage across the LDR is converted into a digital signal and is sent to the microcontroller. These have a potentiometer attached to them to change the sensitivity of the module. In this construction two LDR's connected at two ends of the panel, consequently the sensor experiencing maximum intensity makes the panel turn toward that particular side to harness maximum intensity with the help of DC geared motor which runs clockwise or anti clockwise depending on the which signal is being sent to the controller and through which sensor.

Fig 2. LDR Sensor

2. Microcontroller:

8051 microcontroller (AT89C51) is used here as the control unit or say the brain of the mechanism designed. Two SPST switches are used in place of LDR's, which are connected to the controller. The controller gives the output to the motor driver (L293D) which consequently drives the motor clockwise, anti clockwise or stops the rotation and brings the panel to a halt.

When both sensors are getting equal amount of radiation or else no radiation the microcontroller gives a command implying no rotation of motor. Moreover when LDR 1 receives more radiation it gives command to the motor to rotate anticlockwise and when LDR 2 receives maximum radiation to rotate clockwise.

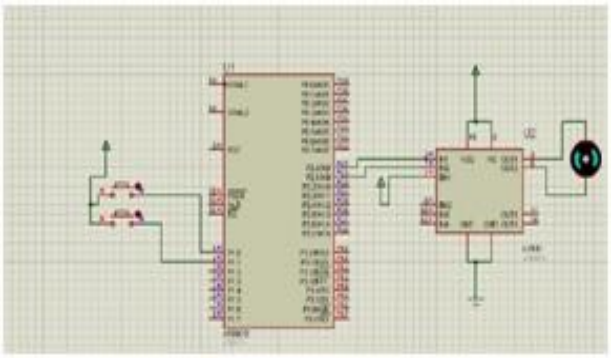

Fig 3. Connection of Microcontroller Unit

3. DC Geared Motor:

A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. DC geared motor used in the prototype is of 12V and 3.5 rpm.

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Fig. 4. DC Geared Motor

IV. OPERATION OF SOLAR TRACKER

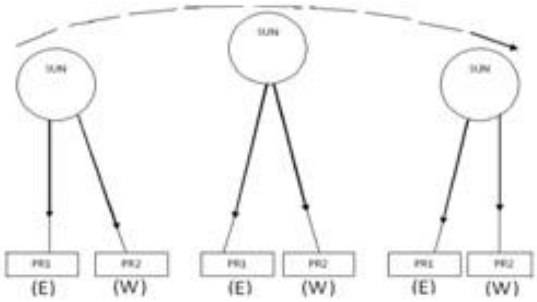

Fig. 5. Positions of Sun

A, B and C show different positions of sun during the day[8] moving from east to west, that is, early sunrise, equal radiation at the panel and when sun is about to set respectively. When the sun is at position B both the sensors are receiving equal amount of radiation and therefore the panel will be at equilibrium position. When at position A the panel will turn towards the East direction implying the motor will rotate anticlockwise and track the maximum radiation. Similarly when at position B the panel will move towards west implying the motor will rotate clockwise making the panel face the maximum radiation of the sun.

V. CLEANING MECHANISM

The panel is subjected to dust throughout the day, so a layer of dust is formed on the panel unavoidably. This reduces the efficiency of the panel. To overcome this limitation a cleaning mechanism can be introduced. With help of a timer circuit a cleaning mechanism is provided for the panel to ensure that the panel is dust free for use the next day. A 12V pump is provided below the panel in a water reservoir, which is driven by a battery to pump up the water through pipes and clean the panel after a stipulated interval of time. The water collected on the panel is again brought down to the water reservoir through an opening given on the mounting of the panel through pipe. The water can be filtered and be used again in order to conserve the valuable resource.

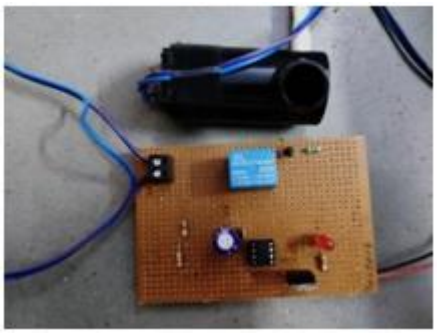

Fig. 6.Timer Circuit and Pump

VI. LOAD CIRCUIT

It is known that a solar panel generates a DC output. Most of the appliances work on AC. So as to convert DC to AC an inverter circuit has been designed. Inverted output is connected to a step up transformer to step up the voltage from 12v to 230V. This voltage then drives a resistive load.

Fig. 7. Load Circuit

VII. PROTOTYPE

Fig. 8. Prototype of Automatic Solar Tracker

VIII. CONCLUSION

The paper has presented a method of tracking the sun's position with the help of microcontroller and a motor driven mechanism. It demonstrates a working solution for increasing solar cell output by positioning a solar

panel at the point of maximum light intensity. The prototype represents a method for tracking the position of sun throughout the day. The appealing feature of the designed solar tracker is simple mechanism to control the system as well as the cleaning mechanism. Though the prototype has limitations in hardware areas as an initial set up, still it provides an opportunity for improvement of the design methodology in future.

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