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Dual Axis Solar Tracking System using Microcontroller with MPPT

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Abstract: Solar energy is becoming popular as an important means of renewable energy resource. This paper will depict, design and construction of Dual Axis Solar Tracker with a view to grab maximum solar energy. The usage of a sun tracking system greatly increases the power gain from solar radiation. Development of solar tracking systems has been in progress for several years now. As the sun's position changes across the sky over the day, the solar tracking mechanism is advantageous. It tracks the location of the sun anywhere in the sky. To produce maximum amount of energy, a solar panel must be perpendicular to the light source. Because the sun moves throughout the day and throughout the year, a solar panel must be able to trace the sun's movement to produce the maximum possible power. In addition, efficiency of solar cell can be significantly increased by a technique called maximum power point tracking(MPPT) that optimizes the match between the solar array (PV panels), and the battery bank or utility grid.
Keywords: Solar tracking system, MPPT, microcontroller, photovoltaic array.

I. INTRODUCTION

In recent years there has been significant advancement infield of solar energy as the major alternative source of renewable energy. When we consider that the power density received from the sun at sea level is about 100 mw/cm^2, it is certainly an energy source that requires further research and development to maximize the conversion efficiency from solar to electrical energy. This document explicitly describes the controlling of solar panel with the help of microcontroller to track maximum solar energy. The precise control of solar panel is done by servo motor. Solar panel consists of a series of solar cells whose output power is provided to the battery for the purpose of storage and it can be provided to the grid. This dual axis tracker is totally interactive in nature because of the microcontroller's properties. We have defined the ports of microcontroller which define the specific functions of the design, such as port1 defines the input signal from the sensor, port2 handles the servo motor, port3 defines the excited solar cells and the converted power is defined by port4. Environmental conditions are also sensed by the microcontroller such as cloudy conditions, etc.

A. *Solar Cell:* A solar cell, or photovoltaic cell , is an electrical device that converts the light energy directly into electricity by the photovoltaic effect, which is both physical and chemical phenomenon. It is a type of photoelectric cell, whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the fundamental blocks of photovoltaic array, also known as solar panels.
B. *Solar Panel:* **-** It is a large component made up of the number of photovoltaic cells connected internally with each other. It is used to grab the sunlight and to convert it into the electricity.
C. *Solar tracker:* A Solar tracker is a device used for changing direction of a solar panel or lens towards the sun by using the solar or light detectors connected with the machine (ex: servo motor, servo motor, gas filled piston). Hence, the sun tracking systems can collect more energy than what a fixed panel system collects.

II. SOLAR TRACKER

This paper depicts the use of a dual axis solar tracker. A dual axis solar tracker tracks the sun in both Azimuthal and Horizontal planes. Azimuth, the angle formed between a reference direction, whatsoever and a line from the observer to a point of interest projected on the same plane as the reference direction orthogonal to the zenith. Whereas the Horizontal plane is the common 180^0 plane.

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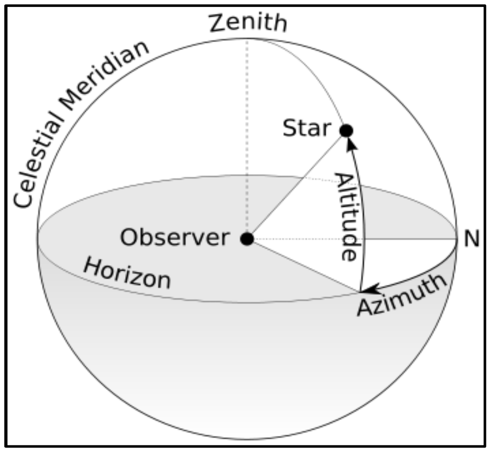

Fig.1 Azimuth and Zenith

Image by TW Carlson - http://commons.wikimedia.org/wiki/File:Azimut_altitude.svg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=17727911

This dual axis solar tracker has Arduino UNO R3 as its heart. The panels track the movement of the sun by help of the motors attached and sensors placed on it. Here LDRs have been used to portray the tracking.In the diagram shown in figure, shows the complete structure of the tracking system. The solar panel is kept on the frame which is rotated by using servo motor. The servo motor is connected to the microcontroller with the help of motor driver. The proposed system consists of a set of two LDRs in X direction and a set of two LDRs in Y direction. These LDRs are mounted on the solar panel. LDR sensors senses maximum solar power which is being given to the microcontroller which has internally build analog to digital convertor. This ADC is of 10 bits. The positional direction of the sun with respect to time has been measured and implemented as an algorithm in the microcontroller. Microcontroller then takes the decision according to the algorithm and tilts the panel towards the direction of maximum solar energy given by LDRs with the help of servo motor. Servo motor is used to rotate the panel in best angle of exposure of light. To drive this motor a driver IC is used. Driver IC amplifies the input voltage and protects the microcontroller from back emf. This may damage the microcontroller. The driver IC used is ULN2003A. It has H bridge internally made up of transistors. Output pins of motor driver IC is connected to the servo motor and input pins are connected to the microcontroller pins. The outputs of the two servo motors are connected to solar panel. When the amount of light intensity falling on the X-axis LDRs is maximum than the Y-axis LDRs then solar panel will move in X direction or vice-versa. By connecting a battery to the solar panel, one can store the energy generated by the solar cells and this energy can be used when required.

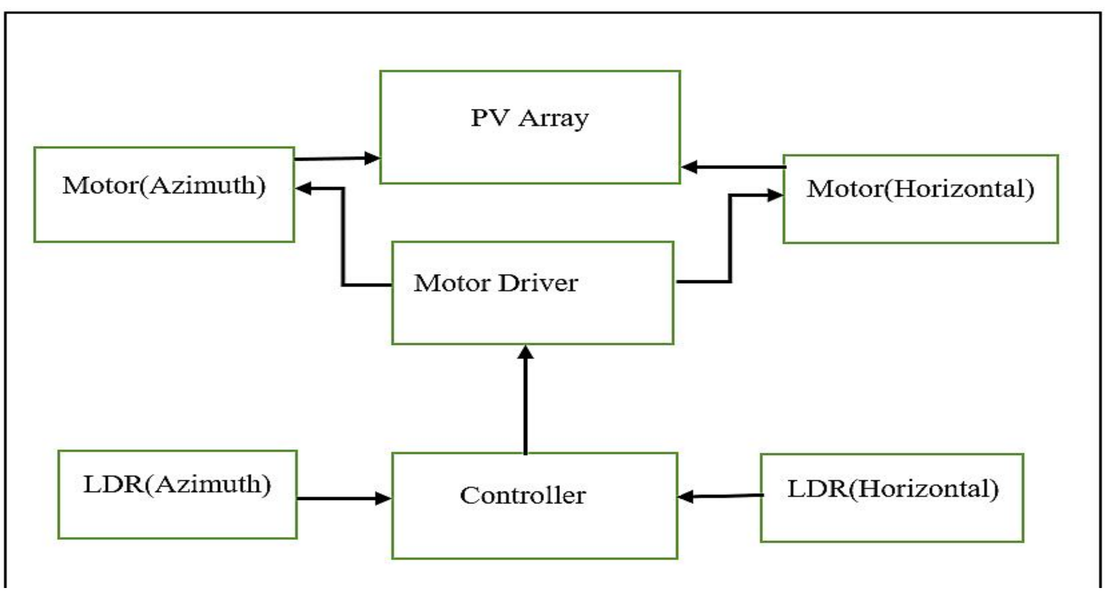

Fig. 2 Block diagram of the dual axis tracker.

III. MPPT (MAXIMUM POWER POINT TRACKING)

Maximum Power Point Tracking is electronic tracking - usually digital. The charge controller looks at the output of the panels and compares it to the battery voltage. It then calculates what best output power can the panel provide to charge the battery. The main agenda behind the MPPT is to extract the maximum power under all weather conditions. This is done by sampling the output of the PV cells and applying the proper load to given sample to obtain the maximum power, no matter what the weather conditions are. Although amount of sunlight being absorbed by the cells affects the amount of load being applied. Most modern MPPT's are around 93-97% efficient in the conversion. You typically get a 20 to 45% power gain in winter and 10-15% in summer. Actual gain can vary widely depending weather, temperature, battery state of charge and other factors. The Maximum Power Point Tracker is a high-frequency DC-DC converter. They take the DC input from the solar panels, change it to high-frequency AC, and convert it back down to a different DC voltage and current to exactly match the panels to the batteries. MPP trackers are usually installed onto a power system which facilitates voltage or current conversion, filtering, and regulation for driving various loads. Solar inverters convert the DC power to AC power and may incorporate MPPT: such inverters sample the output power (I-V curve) from the solar modules and apply the proper resistance (load) so as to obtain maximum power. The power at the MPP (Pmpp) is the product of the MPP voltage(Vmpp) and MPP current(Impp).

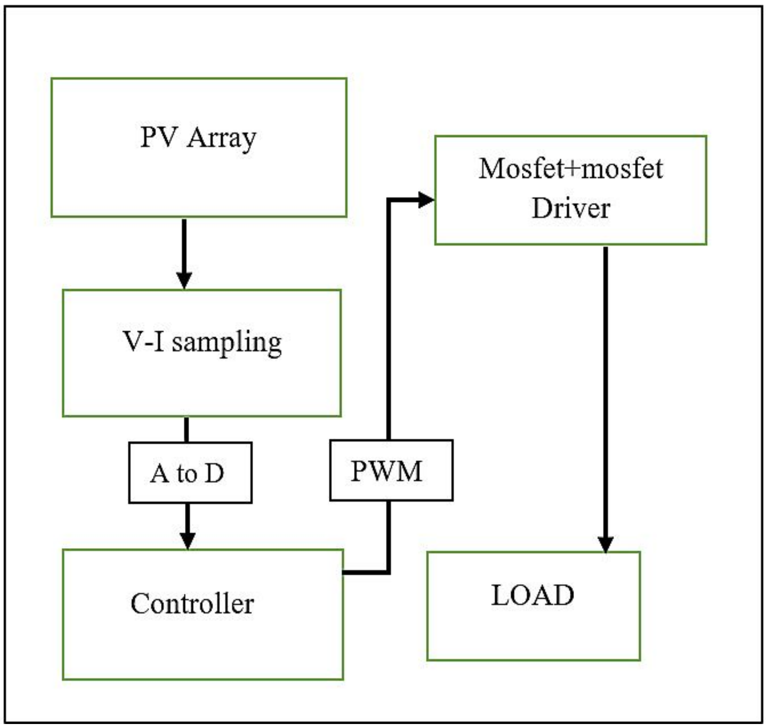

Fig.3 Block diagram of MPPT

PV solar systems exist in many different configurations with regard to their relationship to inverter systems, external grids, battery banks, or other electrical loads. The central problem addressed by MPPT is that the efficiency of power emitted from the solar cell is affected by both, the amount of sunlight falling on the solar panels and the electrical characteristics of the load.

IV. THE ENHANCED SOLAR POWER SYSTEM

After introducing the MPPT in a solar power system and replacing the fixed solar panels with Dual Axis Tracking connected panels, the modified system can be much more efficient. Some other features like smart grid system can be a plus. The solar tracker will constantly keep the track of the sun’s movement in both azimuth and horizontal direction, providing the maximum absorption of the light energy. The MPPT will draw the maximum required power from the panel to charge the battery by matching the load, no matter what the weather conditions are. The solar inverter converts the DC power to AC, for use in household. Additional feature like smart grid acts when the power is in surplus. It means when the required amount of power is full filled the switching mechanism will send back the power to the grid, also helping the consumer to get compensated from the power supply agency.

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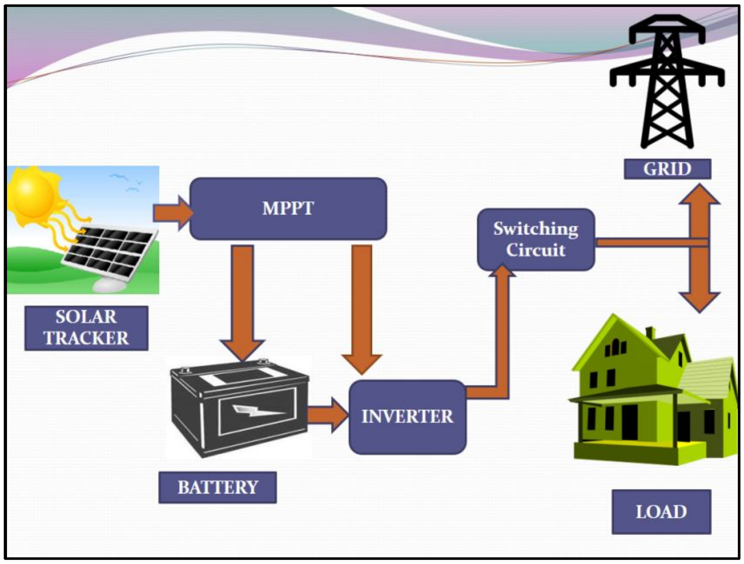

Fig. 4 Block Diagram showing the arrangement of dual axis solar tracker with MPPT.

V. RESULT & CONCLUSION

A. Following Were Observed After The Hardware Implementation Of The Project-

1) When light was incident on the panel, the azimuth motor rotates corresponding to the sensors placed in azimuthal direction and the horizontal motors rotates when light is incident on their corresponding sensors.
2) On replacing the fixed panels with dual axis tracking mechanism, efficiency was increased by 26.22%.
3) The Power Output of the panel was found to be 30% more than the fixed panels.
4) The maximum power point tracker efficiency is above 99% for different ranges of light intensities.

Based on the above results observed, it can be concluded that efficiency of solar cell is increased by a technique called maximum power point tracking(MPPT), by installing this we can get additional 15% to 35% of extra energy depending upon the weather.

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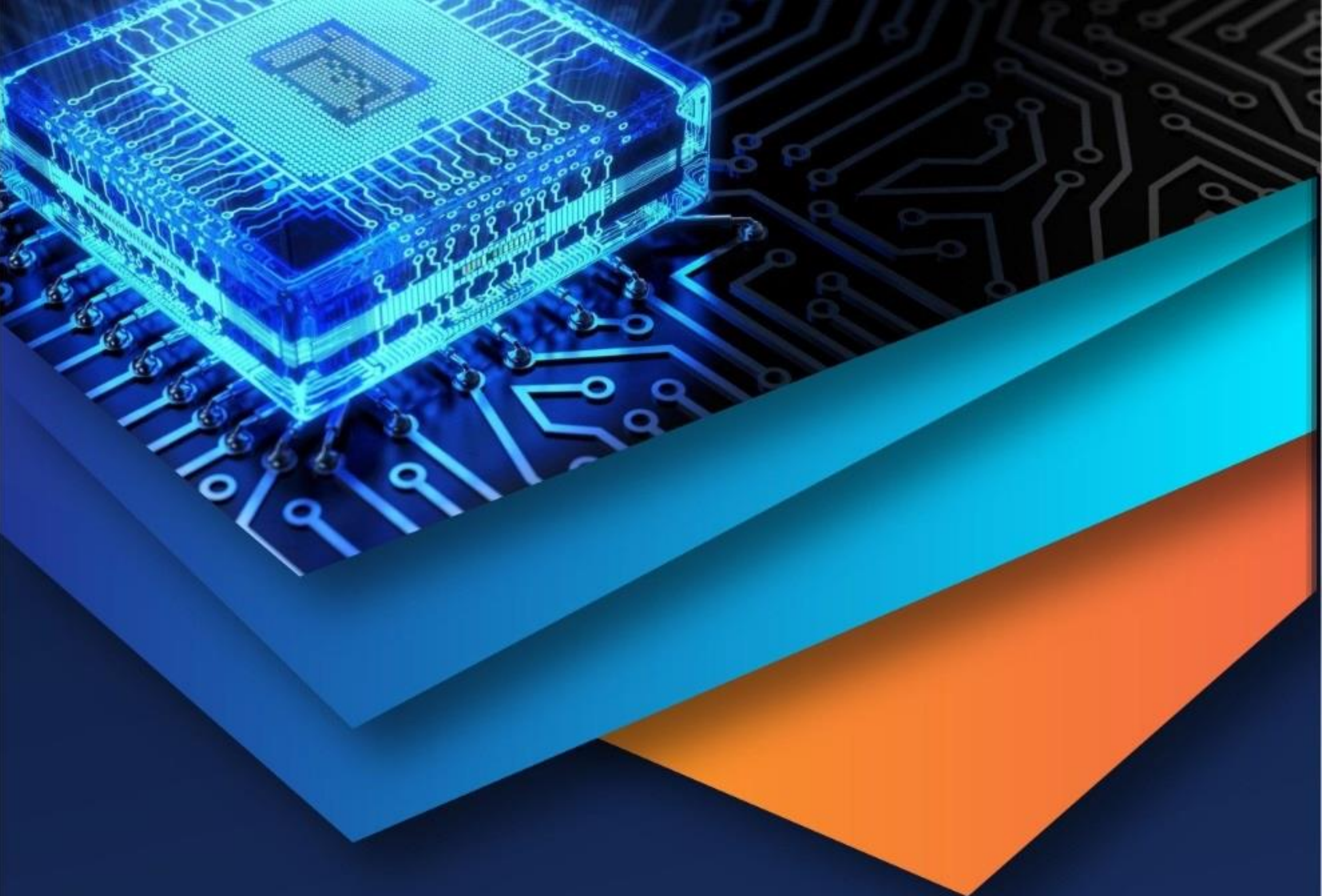

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