OPTIMIZATION AND PERFORMANCE ANALYSIS OF SINGLE AXIS SOLAR TRACKER USING MATLAB/SIMULINK SOFTWARE

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Abstract*—The use of clean energy (Solar, Wind etc) in other words, renewable energy is becoming more important for lowering global warming as the world becomes hotter as a result of global warming . The aim of this paper is to consume the maximum solar energy through solar panel. A Solar Tracker is a device onto which solar panels are built-in which tracks the motion of the sun ensuring that maximum amount of sunlight strikes the panels all over the day. Power output from a solar cell will be high when it is facing the sun. The simulation provides the design of solar tracking system . The performance and characteristic of the solar tracker are analyzed using MATLAB/SIMULINK platform. The simulation part is done with solar PV cell characteristics, amplifying voltage , controller unit and ARDUINO Servo Unit.

***Index Terms*— solar tracker, MATLAB/SIMULINK, PV cell, Efficiency, amplifier.**

I. INTRODUCTION

Life on the earth planet is the manifestation of energy. The origin of fire, heat and light is energy. Thermal plants (coal, oil, gas) ,nuclear and hydro power stations are the major conventional methods of generating electrical energy. Rise in the cost of fossil fuels has created an urgency to conserve these fuels, and engineers across the world are looking for alternative renewable sources of energy. Renewable energy sources occur in nature which are regenerative (or) exhaustible like solar energy , wind energy , hydro power , geo thermal , biomass ,tidal and wave energy. Most of these alternative sources are the manifestation of solar energy. Solar PV panels directly convert radiation from the sun into electrical energy. Their efficiency is 24.5% on the higher side. Three possible ways of increasing the efficiency of the solar PV panels are through increase of cell efficiency, maximizing the power output and the use of a tracking system. For places around the equator where there is no significant change in the apparent position of the sun, single axis trackers are best option. The efficiency of the tracking system and weather are the key roles to indicate how much level the efficiency is to be improved.

II. TYPES OF SOLAR TRACKERS

A solar tracker is a device which rotates towards the sun's direction hence ensuring that it is always exposed to the sun no matter the time of day or location of the panel. The single axis trackers follows the sun's trajectory from east to west throughout the day. They have one degree of freedom which act as the axis of rotation. A single linear actuator (motor) is used to drive the panel according to the sun movements. Various types of single axis trackers are horizontal single axis trackers (HSAT), horizontal single axis tracker with tilted modules (HTSAT), vertical single axis trackers (VSAT), tilted single axis trackers (TSAT) and polar aligned single axis trackers (PSAT).

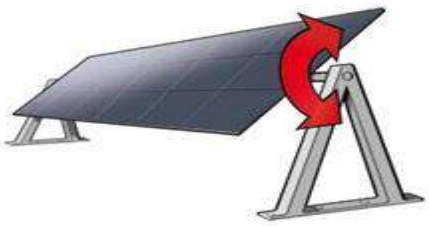

Fig 1. Single axis tracker

Dual Axis trackers have two degrees of freedom added to the system. For maximum absorption of sunlight, the panel can move both in east-west and north-south direction. Since two linear actuators are used , they are more efficient than the single axis solar trackers.

Fig 2. Dual axis tracker

III.SOLAR RADIATION CONCEPT

For utilization of solar energy , a study is carried out of radiations received on the earth's surface . Solar radiations pass through the earth's surface . Solar radiations pass through the earth's atmosphere and are subjected to scattering and atmospheric absorption . Apart of scattered radiations is reflected back into space. Sunlight has two components, the direct beam and diffuse beam. Solar radiation received on the earth's surface without change in direction, is called beam (or) direct radiation. Diffuse radiation is that solar radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere. The total solar radiation received at any point on the earth's surface is the sun of the direct and diffuse radiation. In general sense, it is referred as the insolation at the point. Most of the sun energy is in the direct beam, so maximum collection requires the sun to be visible to the panels as long as possible.

IV. WORKING OF SOLAR PHOTO VOLATAIC

A solar PV cell converts the energy of light directly into electricity by the photovoltaic effect. PV / Solar cells are framed in series and in parallel to form a PV / Solar Panel (Module). The number of series cells indicates the voltage of the Panel (Module), whereas the number of parallel cells indicates the current. PV Array is a combination PV modules in series and parallel.

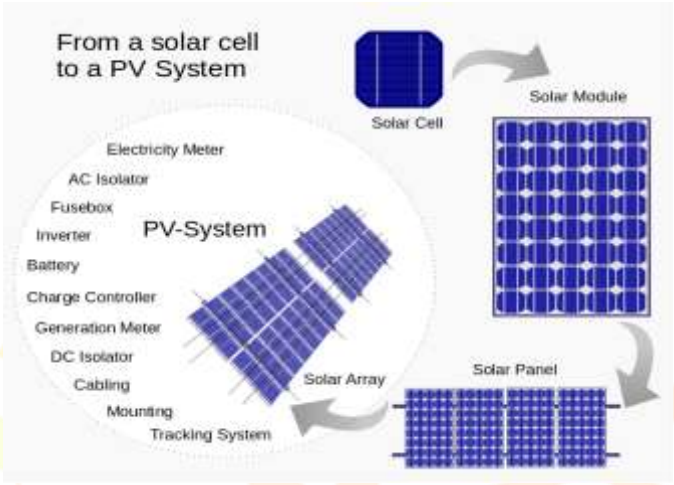

Figure 3. Photovoltaic panel or array

V. EFFICIENCY OF SOLAR PANELS

Efficiency is the most commonly used performance parameter from one solar cell to another cell. It is the ratio of energy output from the solar panel to input energy from the sun. The performance of the solar cells also assesses on the solar spectrum, solar intensity and the temperature of the solar cell. So efficiency is the major thing to be measured and must be controlled to compare the performance of various devices.

VI. MODELING OF SOLAR TRACKER:

The performance and characteristic of the solar tracker are analyzed using MATLAB/SIMULINK platform. The simulation part is done with solar PV cell characteristics, amplifying voltage , controller unit and ARDUINO Servo Unit. The PV tracking cells detects light intensity and convert it into current. They are mounted on two 45 degree wedges to detect the exact angle in which the main solar panel must face to gain maximum power output. The current is amplified using the signal conditioning circuit, and sent to the microcontroller. Using different control algorithms, the microcontroller generates a signal which control the motor to rotate the main solar panel perpendicular to the sun. The control algorithm is simulated by an embedded MATLAB function and generates PWM signal to drive the motor.

VII. SOLAR TRACKING CELL MODEL

A solar tracking cell generates current when light incident falls on its surface. Amount of current is proportional to the light and determined by the flux density. The model of the solar cell can be found in the library of sources in Sim Electronics. . Figure 4. shows the implementation of solar cell module in SIMULINK.

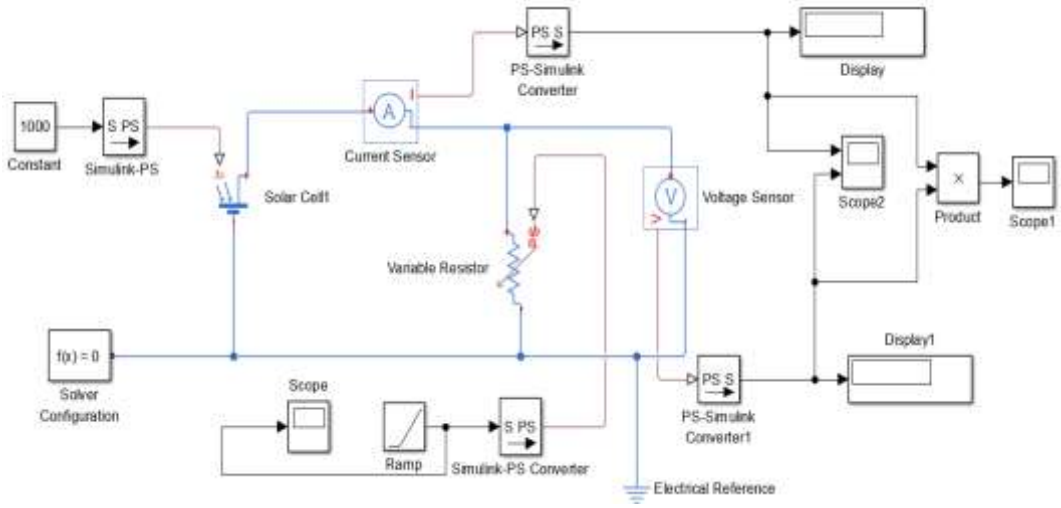

Figure 4. solar Tracking cell module in SIMULINK

VIII.SIGNAL CONDITIONING UNIT

Two small solar panels have a voltage rating of 600 mV, while the analog-to-digital converter (ADC) of the microcontroller will accept input voltage from 0 to 5 V. A***n amplifying voltage*** circuit is designed and built to interface between the small solar panels and the microcontroller. By using an operational amplifier , a non-inverting amplifier is built. The voltage gain of the non-inverting amplifier is designed to be 10. Simulation of the non inverting amplifier is shown in figure 5, which provides a gain of 10.

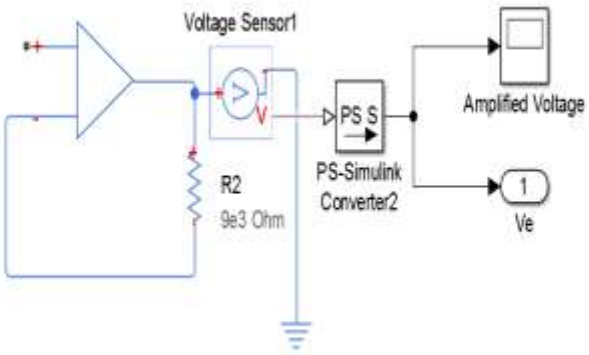

Figure 5. Simulation model of the signal conditioning unit

IX. CONTROLLER UNIT

The control algorithm is simulated by an embedded MATLAB function .The first block is initialized and it turns ON power for all components. After that output voltage of the east and west tracking cells are added to determine if it is day time or night. The program will repeat the loop, if it is night. After sunrise, the program will jump out of the loop and proceed to daytime tracking loop. There are three situations based on the output voltage from east and west tracking cells. If the maximum rotation steps are reached, the controller will go to the night mode state. It will first rotate clockwise until the steps number is equal to 0 and then it starts to go into the sleeping state for certain delay period of time until sunrise. The embedded MATLAB function allows convenient evaluation and modification of the control algorithm. The figure 6 shows the control algorithm for solar tracking system.

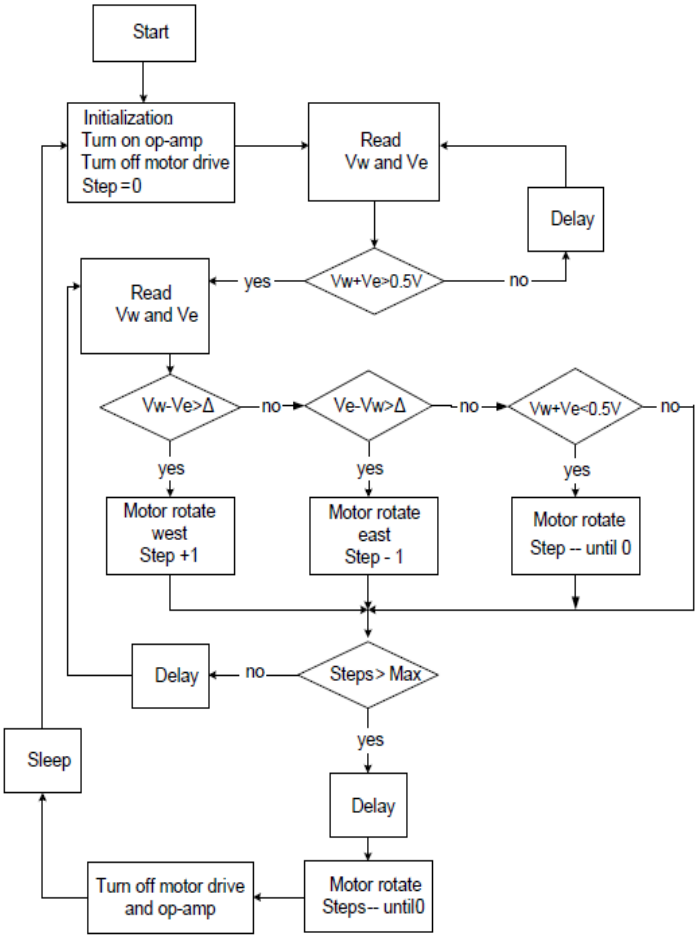

Figure 6. the control algorithm for solar tracking system

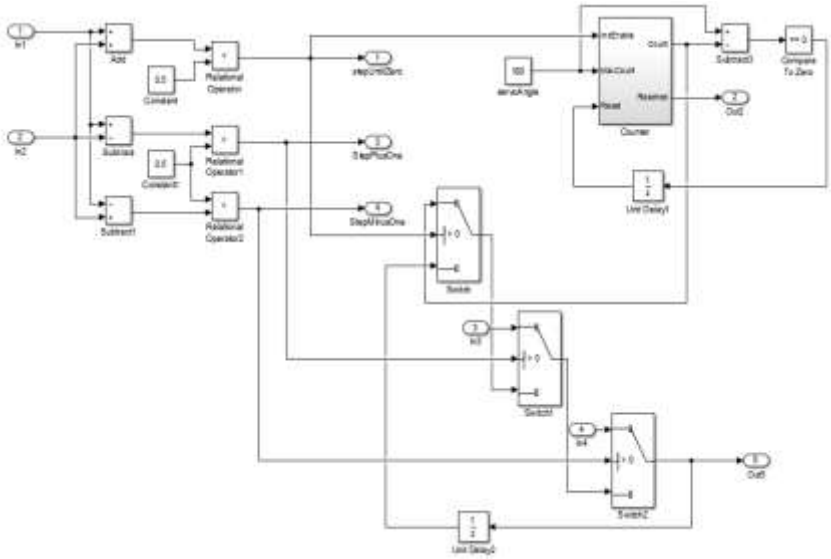

Figure 7. Controller model in SIMULINK

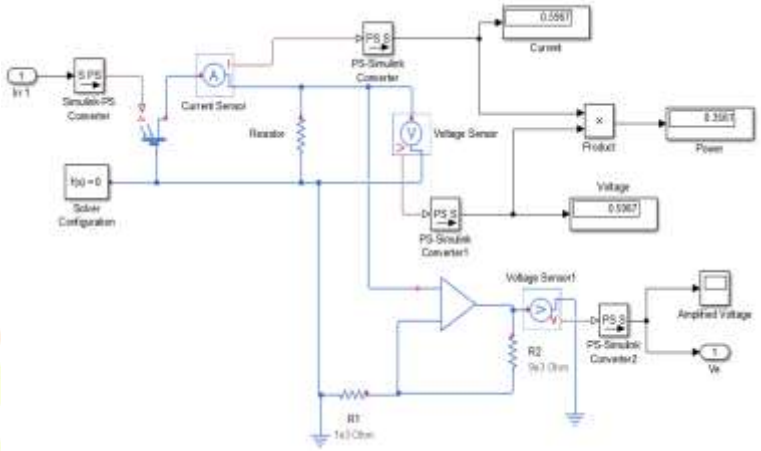

Figure 8. Input to controller model

X.INTEGRATED MODEL

The simulation of the tracking solar cells, signal conditioning, control and stepper motor is integrated, which completes the simulation for the sun tracking solar power system. The system is a feedback control system, as the angle of the main panel is sensed and sent back to the input of the system. . The figure 9 shows integrated model of the solar tracking system.

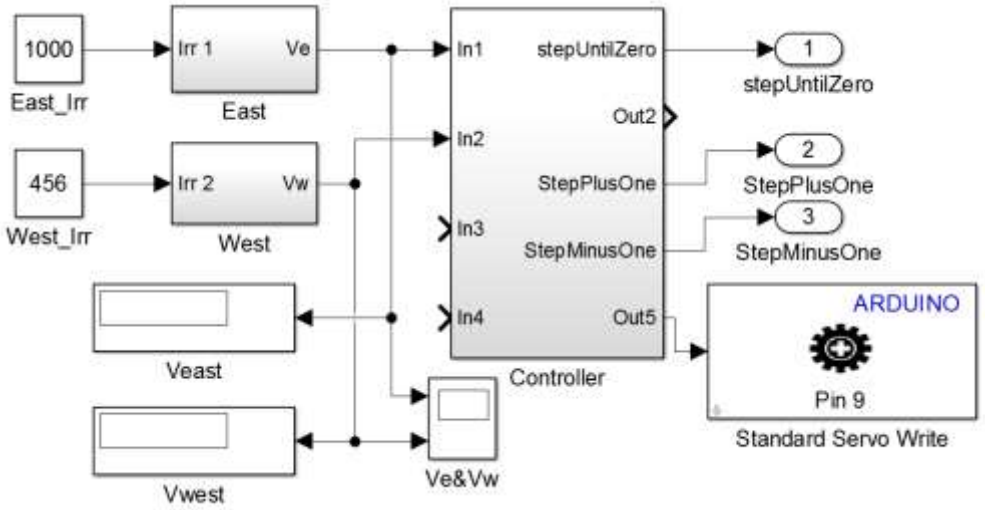

Figure 9. Integrated circuit of the solar tracker in MATLAB/SIMULINK

XI. SIMULATION OUTPUTS

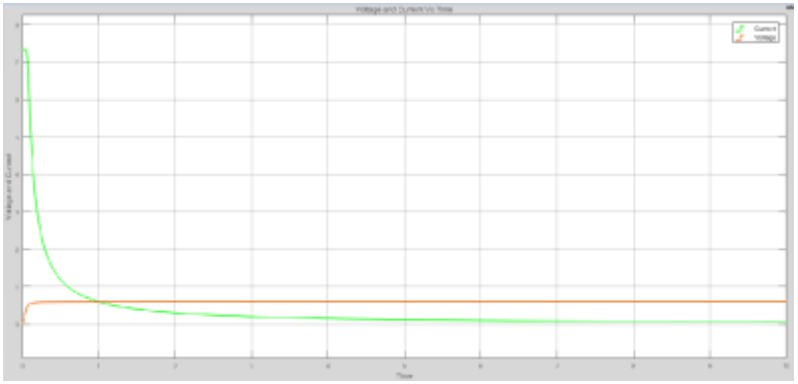

Figure 10. Voltage and Current Vs Time

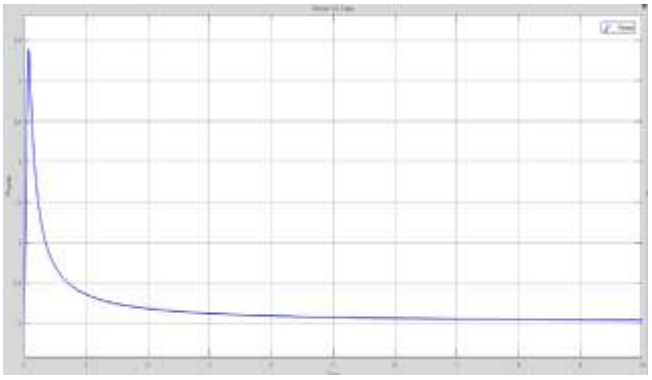

Figure 11. Power Vs Time

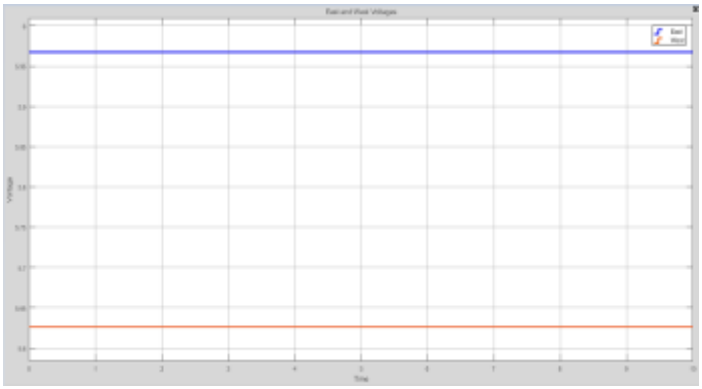

Figure 12. East and West Voltages for irradiance 1000 and 456KW/m^2

XII.CONCLUSION

Solar tracking system is an efficient means of obtaining optimal solar energy from the sun. By constantly aligning the photovoltaic panel with the sun, it directly receives sunlight falling on its surface there by generating more electricity. Different techniques have been adopted in the design of this system but the method implemented in this paper is simple. In order to design and simulate the system ,we have glance of exposure on circuit theory, power electronics, microcontrollers, electric machines, and solar power .The MATLAB/SIMULINK simulation provides an excellent platform to study the theory and explore different designs for the sun tracking solar system. After testing and verification using the simulation, a prototype system will be built in the laboratory.

XIII. REFERENCES

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