International Journal of
Science and Engineering Investigations vol. 1, issue 10, November 2012
ISSN: 2251-8843

Prototype Development of Voltage Based Solar Tracker Algorithm

Savitha G. Kini[1], R. S. Aithal[2], Arpit Gandhi[3]
[1,2,3]Manipal Institute of Technology, Manipal
([1]savithakini@yahoo.com, [2]drrsaithal@gmail.com, [3]arpit009@gmail.com)

Abstract- Energy has been recognized to be one of the most important inputs for national development. The depletion of conventional energy sources is occurring at a faster rate due to enhancing gap between supply and demand. It is therefore evident that harnessing energy from renewable sources for sustain the energy requirement is need of the hour. Photovoltaic energy could be an answer to that need. Despite high capital cost, PV systems are still viable solution for rural areas. The output of PV cells depends on the intensity of sun light and angle of incidence. To get the maximum efficiency, the solar panels must remain in front of sun during the whole day. But due to rotation of earth the panels cannot maintain their position always in front of sun. This problem results in decrease of their efficiency. Tracking of sun is throughout the day is necessary to maximize the efficiency. This paper discusses the prototype development of voltage based solar tracking algorithm implemented on embedded system platform without the use of Light dependent resistor. The result shows the efficiency enhancement of the system by 13 percent over system without tracker.

Keywords- *Solar tracking; Efficiency; Embedded system.*

I. INTRODUCTION

Energy has been recognized to be one of the most important inputs for national development. The depletion of conventional energy sources is occurring at a faster rate due to enhancing gap between supply and demand. It is therefore evident that harnessing energy from renewable sources for sustain the energy requirement is need of the hour [1]. The renewable energy sources can be recycled such as solar energy, wind energy, biomass energy tidal energy etc. Among them solar energy is the most powerful resource that can be used to generate power and Photovoltaic technology could be an answer to that need. Despite high capital cost, PV systems are still viable solution for rural areas. The materials used in PV cell manufacturing limit the efficiency of PV cell. This makes it particularly difficult to make considerable improvements in the performance of the cell, and hence restricts the efficiency with a peak laboratory efficiency of 32% and average efficiency of 15-20% of the overall collection process [2]. Therefore, the most attainable method of improving the performance of solar power collection is to increase the mean intensity of radiation received from the source.

A solar PV panel in oriented at fixed elevating angle cannot obtain the optimal energy as the output of PV cells depends on the intensity of sun light and angle of incidence. A solar tracker is an electromechanical device for orienting a solar photovoltaic panel towards the sun. Solar tracker maximizes the energy that can be transferred from the array to an electrical system. Many authors[3-6] proposed sun tracking system with light intensity sensors such as LDR's (Light Dependant Resistors) to track the light from the sun and hence orient the panel in the direction of the sun. The LDRs are placed at the two extremes of the solar panel and when the light intensity becomes same they align towards the sun. Use of LDRs in the solar panels for tracking the motion of the sun has many drawbacks, since the amount of light falling on both LDRs can be same and this can lead to false triggering of the driving system and hence waste power. To overcome this problem the voltage generated by the solar panel is itself taken and fed into the ADC of the microcontroller, thereby eliminating the use of any additional sensor. This paper analyses the energy efficiency of the solar tracking system implemented on an embedded system platform based on voltage sensing algorithm.

II. BLOCK DIAGRAM

'Fig.1' shows the block diagram of implementing a sun tracking system which is very different from the conventional light dependant sensor based tracking system. The panel itself acts as the sensor and aligns itself in that direction where it produces the maximum voltage. The implementation scheme is on embedded software control AVR 40 pin rapid robot controller board V2 include the microcontroller which is the heart of the system[7]. The board includes ATMEGA 32 microcontroller, L298 motor driver IC, 12 volt high Torque 60 rpm PMDC motor. To enhance the torque of the motor even further an 18 teeth sprocket along with a 16 teeth sprocket on the motor is used. A voltage divider network is used to feed the voltage values of the solar panels to the microcontroller's inbuilt ADC as the solar panel itself being used as a sensor. The working algorithm then commands the high torque DC motor to move either forward or backward through the motor driver IC.Maintaining the Integrity of the Specifications

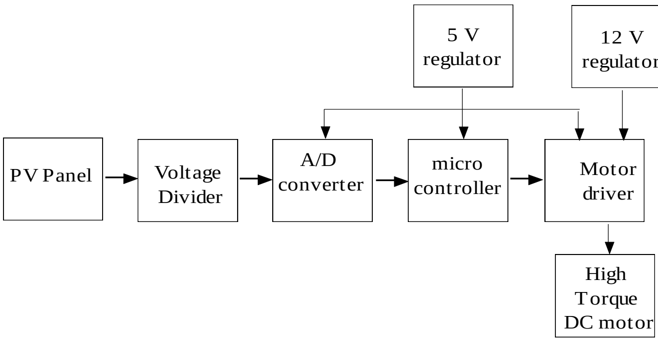

Figure 1. Solar tracker control Block Diagram

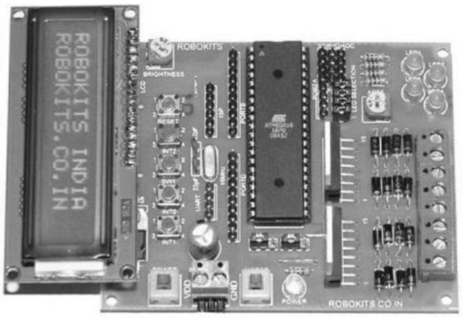

Figure 2. AVR 40 pin rapid robot controller board V2

ATMEGA 32 microcontroller features:

- Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
- One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
- Real Time Counter with Separate Oscillator
- Four PWM Channels
- 8-channel, 10-bit ADC on chip
  8 Single-ended Channels
  7 Differential Channels in TQFP Package Only
  2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
- Byte-oriented Two-wire Serial Interface
- Programmable Serial USART
- Master/Slave SPI Serial Interface
- Programmable Watchdog Timer with Separate On-chip Oscillator
- On-chip Analog Comparator

Motor features

- 60RPM 12V DC motors with Metal Gearbox
- 25000 RPM base motor
- 6mm shaft diameter
- Gearbox diameter 37 mm.
- Motor Diameter 28.5 mm
- Length 63 mm without shaft
- Shaft length 15mm

Tracking Algorithm

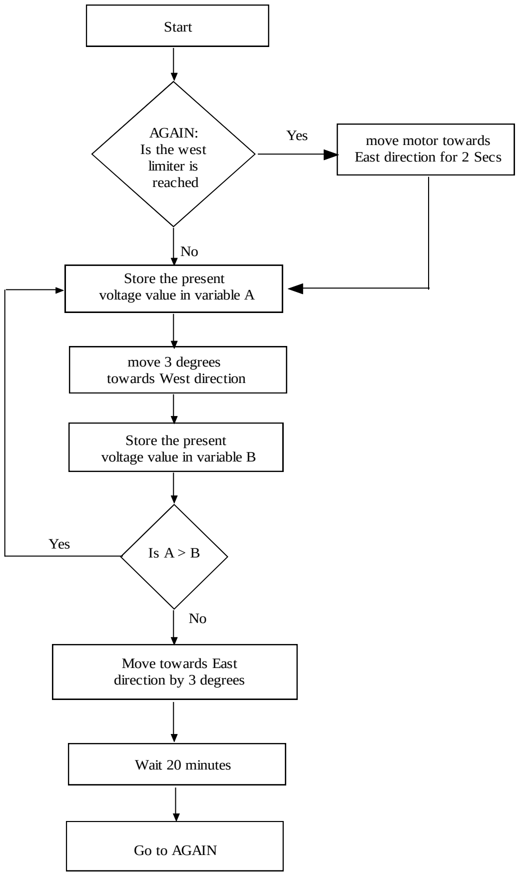

Figure 3. Working control Algorithm

The algorithm works by first checking the west limiter condition, if the west limiter is reached then the motor is given power for about 2 seconds and is restored back to the starting condition. If not then the voltage of the present position is stored and the panel is moved by 3 degrees in the west direction, again at this the value of the voltage is stored and compared with the previous value. If this value is greater than the previous value then this process is repeated till the time the next value decreases. At this point the panel is moved towards the east direction by 3 degrees, and is held at this position for duration of about 20 minutes and again the entire algorithm is repeated.

III. Prototype Testing

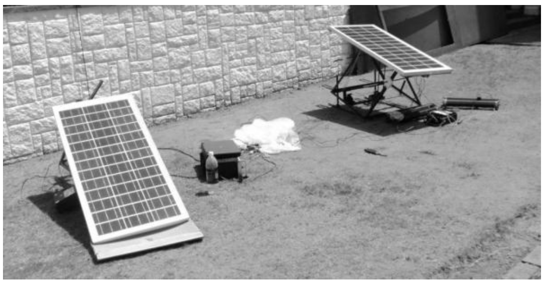

Figure 4: Testing of solar tracker with stationary tracker for comparison

The developed algorithm was tested on solar panel of 75 Wp with maximum power point at about 17.4V @ STC. The testing of the solar tracker was done for two days at the MIT quadrangle. The testing was done from 10am in the morning to 4pm in the evening even for the SPV system of the same specification without tracker. Readings were taken at every 20 minutes from the starting of the test till the end. Figure 5 and Figure 6 shows the power output of the panels with and without tracking.

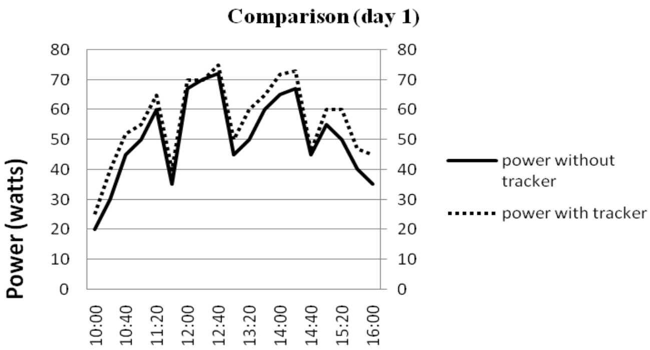

Figure 5. Output power vs Time of the day

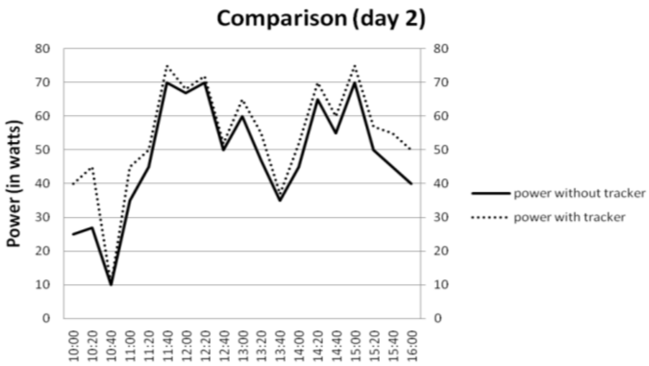

Figure 6. Output power vs Time of the day

IV. RESULT ANALYSIS

From Figure 5 and Figure 6, it is evident that there is appreciable enhancement of power output with tracking mechanism. The increase in efficiency by using the voltage based solar tracking system is around 11.34% on day 1 and around 13.39% on day 2. The tracking results are best during the morning and the evening. The results don’t show much improvement during mid noon when the sun is directly above both the panels and during the cloudy conditions when the sunlight is diffused in the environment. The power consumed by the motor and electronics in standby mode is around 0.9 watts, but during the motion phase the power required is around 9 watts but this power is only needed for 80 ms, when the motor moves either forward or backward.

V. CONCLUSIONS

Voltage based mechanical solar tracker is a very simple algorithmic approach and is better than the LDR based solar tracker approach. The developed solar tracking system tracks the sun automatically and thus increases the energy generation efficiency. Thus the proposed sun tracking solar array system is a feasible method of maximizing the energy received from solar radiation

REFERENCES

[1] Y. J. Huang, Member, IAENG, B. C. Wu, C. Y. Chen, C. H. Chang, and T. C. Kuo, Member, IAENG, “Solar Tracking Fuzzy Control System Design using FPGA Proceedings of the World Congress on Engineering 2009” Vol I WCE 2009, July 1 - 3, 2009, London, U.K www.iaeng.org/publication/WCE2009/WCE2009_pp340-344.pdf

[2] J.Rizk and Y Chaiko, “Solar Tracking system: more efficient use of solar panels”, World Academy of Science, Engineering & Technology 41, 2008 *idari.mu.edu.tr/data/03060010/belgeler/**solar**%20**tracking**.pdf*

[3] D. A. Pritchard, “Sun tracking by peak power positioning for photovoltaic concentrator arrays”, *IEEE Contr. Syst. Mag.*, vol. 3, no. 3,pp. 2-8, 1983.

[4] A. Konar and A. K. Mandal, “Microprocessor based automatic suntracker,” *IEE Proc. Sci., Meas. Technol.*, vol. 138, no. 4, pp. 237-241,1991.

[5] B. Koyuncu and K. Balasubramanian, “A microprocessor controlled automatic sun tracker,” *IEEE Trans. Consumer Electron.*, vol. 37, no. 4,pp. 913-917, 1991.

[6] J. D. Garrison, “A program for calculation of solar energy collection byfixed and tracking collectors,” *Sol. Energy*, vol. 72, no. 4, pp. 241-255, 2002.

[7] AVR 40 pin rapid robot controller board user manual http://www.robokits.org

Savitha G. Kini, born in a city Pankaje, in India in the year 1969. She obtained her B.E degree in electrical & electronics in the year 1991 from Mysore University. Masters degree in Lighting Science & engineering from Mangalore University in 1997 and Ph.D degree from jadavpur University, Kolkata in 2008.

She is currently working as a Professor in the department of electrical & electronics in Manipal Institute of technology, Manipal. She was worked as a consultant on photometric testing of lighting fixtures and involved in design verification of lighting systems of Kandla port trust in India. She has published research papers in international Journal & conferences. Her research interests include solid state lighting and controls, Energy management and renewable energy systems.

Prof. Kini is member of Indian Society of Technical education, Indian Society of Lighting Engineers, Institution of Electrical Engineers(India), and Systems Society of India.