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Design of Sun Tracker Full Duplex by Using Arduino

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Abstract: The dual threats of energy depletion and global warming place the development of methods for harnessing renewable energy resources at the center of public interest. Solar energy is one of the most promising renewable energy resources. Sun trackers can substantially improve the electricity production of a Photovoltaic (PV) system. This study proposes a novel design of a dual-axis solar tracking PV system which utilizes the feedback control design along with a four-quadrant Light Dependent Resistor (LDR) sensor and simple electronic circuits to provide robust system performance. The proposed system uses a unique dual-axis AC motor and a stand-alone PV inverter to accomplish solar tracking. The control implementation is a technical innovation that is a simple and effective design. In addition, a scaled-down laboratory prototype is constructed to verify the feasibility of the scheme. The effectiveness of the sun tracker is confirmed experimentally. The results of this study may serve as valuable references for future solar energy applications.

Key words: Sun tracker, photovoltaic, Arduino and full duplex, energy, confirmed, accomplish

INTRODUCTION

In the United States, the top three energy sources of electricity are coal at 37%, natural gas at 30% and nuclear at 19% (Muneer *et al*., 2005; Mousazadeh *et al*., 2009). These forms of energy are nonrenewable meaning they will eventually be depleted. For this reason it is important to seek renewable sources of energy for they are cleaner, easier to use, require less maintenance and will always be available.

This project focuses on solar energy which is a renewable form of energy. On average the earth surface receives about 600 W/m^2 of solar energy (Mousazadeh *et al*., 2009; Jazayeri *et al*., 2013). This value depends on several factors such as the time of the day and the atmospheric conditions. In 2012, only 0.11% of solar energy was used to generate electricity (Muneer *et al*., 2005). It is estimated that solar energy will become the largest source of electricity by the year 2050 (Mousazadeh *et al*., 2009). For this reason there should be a larger investment in harnessing solar energy.

People who live in secluded areas have limited access to efficient power because it is unavailable or too expensive. Also, with the rising cost of fossil fuel most people who live in standard-sized homes are interested in finding alternative energy sources to reduce domestic electricity cost. Solar energy is an abundant source of renewable energy which makes it a good solution for people living under these circumstances. In a single day, the amount of sunlight hitting the United States is more than 2,500 times the entire country's daily energy usage (Bawa and Patil, 2013; Li, 2012).

The most efficient solar panels of today's technology harness <20% of available solar energy (Sahni, 2015). Although, this is a small percentage, it is a helpful amount of energy that may one day allow for independence from nonrenewable forms of energy. This study provides the description of a senior design student project including the goal of the project and the design specifications. Feasibility and merit criteria detailing the critical and desired attributes of the design are included.

All designs are revealed via. engineering sketches, drawings, discussion and engineering analysis to predict the performance of the designs in relation to the specifications. Conclusions consisting of the best design, the recommendations and the costs of the prototypes are also presented and discussed (Sulaiman, 2014).

MATERIALS AND METHODS

Arduino: Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible. It's an open source physical computing platform and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors and controlling a variety of lights, motors and other physical outputs. Arduino has some advantages for educational and

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interested recreational over other systems like inexpensive, open source and extensible software, extensible hardware (Melgar *et al*., 2012).

Solar system: Solar systems are one of the processes to convert the sunlight energy to electrical energy. Solar cell is the electrical devices that will produce the electricity. It is also known as the photovoltaic cell or photocell. The process of receiving and collecting the light is by using the solar panel. Most of the solar panel nowadays has the thickness range of 3-6 cm and in square shape for easy installation. Figure 1-10 show the process of the system (Datta *et al*., 2014).

Photovoltaic effect: In general, the Photovoltaic effect (PV) can be described as a generation of an electromotive force (voltage) within the range of materials non-homogeneity during light illumination with an appropriate wavelength. Only in specially prepared structures, the effect is high enough and can be applied for conversion of electromagnetic radiation into electricity (Yu *et al*., 2011).

It is also, known as the basic physical process through which a PV cell converts sunlight directly into electricity. PV technology works anytime the sun is shining but more electricity is produced when the light is more intense and when it strikes the PV modules directly which is when the sunrays are perpendicular to the PV modules (Gastelo-Roque and Morales-Acevedo, 2017).

Unlike the solar system for heating water, PV does not produce heat to make electricity. Instead, PV cells generate electricity directly from the electrons freed by the interaction of radiant energy with the semiconductor materials in the PV cells. Sunlight is composed of photons. When it strikes a PV cell, it can be reflected or absorbed, the energy of the photons is transferred to electrons in the atoms of the solar cell which is a semiconductor.

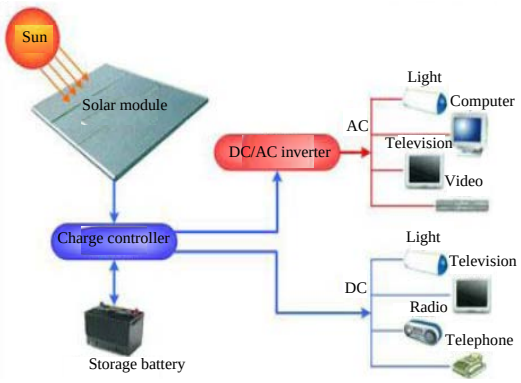

Fig. 1: The process of solar tracker system (Datta *et al*., 2014)

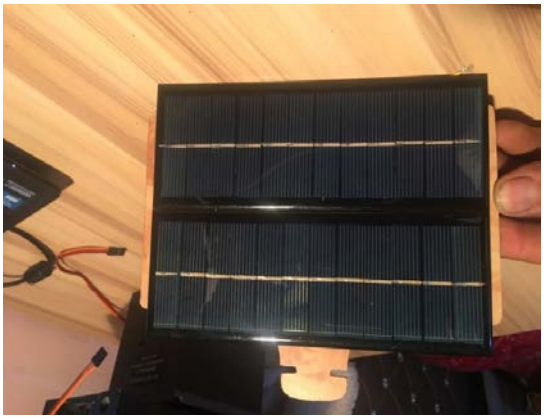

Fig. 2: Solar tracker cells

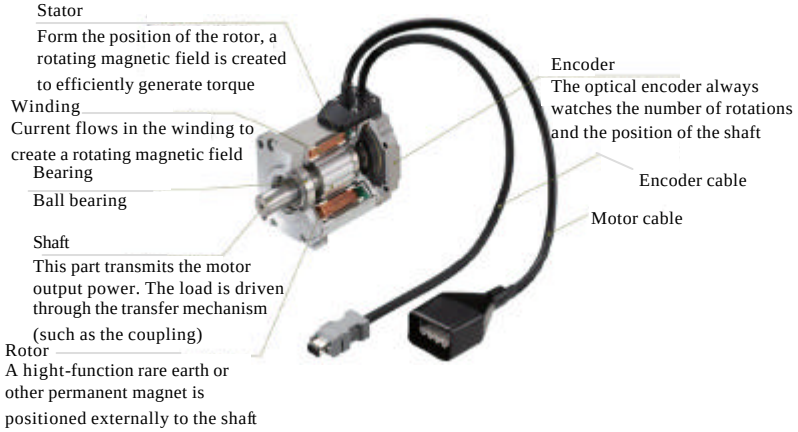

Fig. 3: Servo motor

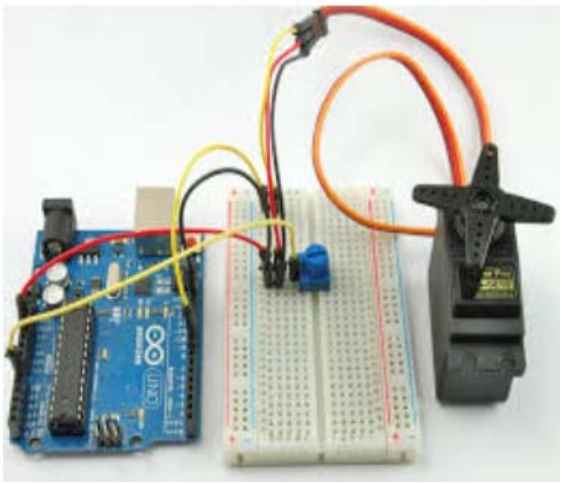

Fig. 4: Arduino servo motor

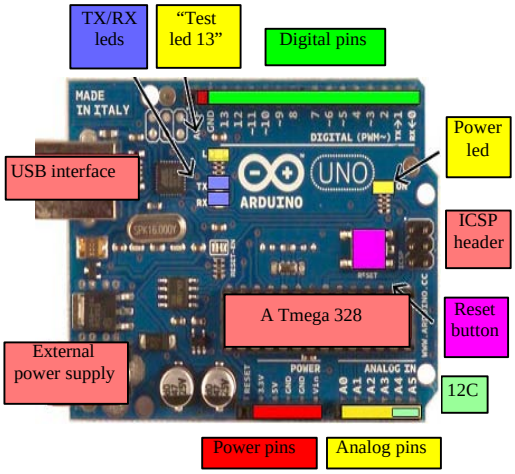

Fig. 5: Arduino Uno

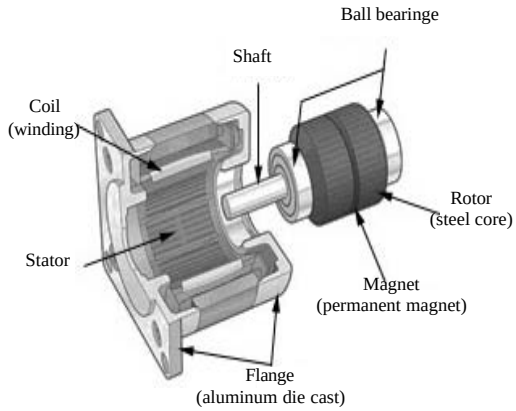

Fig. 6: Construction of stepper motor

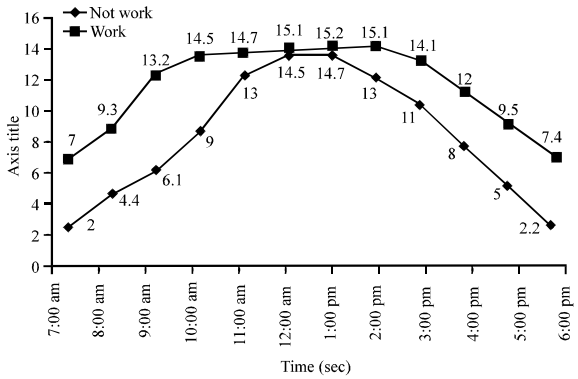

Fig. 7: Output voltage comparative of solar panel

Fig. 8: Product of solar cells

Fig. 9: Component of project

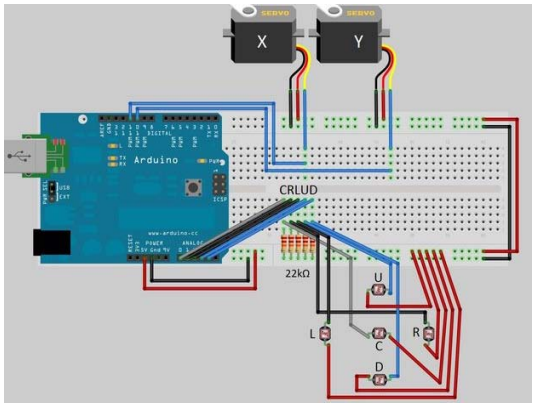

Fig. 10: Block diagram of project

The newfound energy makes the electrons able to escape from its normal positions associated with the atoms to become part of the current in an electrical circuit. By eaving its positions, the electrons cause holes to form in the atomic structure of the cell into enabling other electrons to move. Special electrical properties of the PV cell, a built in electric field, provides the voltage needed to drive the current through a circuit and power up an external load such as a light bulb (Kong *et al*., 2017).

RESULTS AND DISCUSSION

System model

Sun tracker: The amount of force or power when applied can move one object from one position to another or the capacity of a system to do work is called energy. It exists in everybody whether they are human beings or animals or non-living things. There are many forms of energy such as: kinetic, potential, light, sound, gravitational, elastic, electromagnetic or nuclear. According to the law of conservation of energy, any form of energy can be converted into another form and the total energy will remain the same. Energy can be broadly classified into two main group's i.e., renewable and non-renewable resources. Many of the renewable energy a technology have been around for years and as the time go by are increasing in efficiency (Heperkan, 2017).

Servo motor: A servo motor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically, for use with servo motors. A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is some signal, either analogue or digital, representing the position commanded for the output shaft (Firoozian, 2014; Nakamura *et al*., 2004).

Arduino Uno: The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack an ICSP header and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter (Margolis, 2011).

Stepper motor: A stepper motor or step motor or stepping motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller) as long as the motor is carefully sized to the application in respect to torque and speed. Switched reluctance motors are very large stepping motors with a reduced pole count and generally are closed-loop commutated.

Brushed DC motors rotate continuously when DC voltage is applied to their terminals. The stepper motor is known by its property to convert a train of input pulses (typically, square wave pulses) into a precisely defined increment in the shaft position. Each pulse moves the shaft through a fixed angle. Stepper motors effectively have multiple "Toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external driver circuit or a micro controller.

To make the motor shaft turn, first, one electromagnet is given power which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of those rotations is called a "step" with an integer number of steps making a full rotation. In that way the motor can be turned by a precise angle (Bista, 2016; Parmar *et al*., 2017).

CONCLUSION

Solar radiation tracker has played a vital role in increasing the efficiency of solar panels in recent years, thus, proving to be a better technological achievement. The vital importance of a dual axis solar tracker lies in its better efficiency and sustainability to give a better output compared to a fived solar panel or a single axis solar tracker.

The tracking system is designed such that it can trap the solar energy in all possible directions. Generally in a single axis tracker that moves only along a single axis it is not possible to track the maximum solar energy. In case of dual axis trackers, if the solar rays are perpendicular to panel throughout the year. Hence, maximum possible energy is trapped throughout the day as well as throughout the year. Thus, the output increases indicating that the efficiency more than a fixed solar panel (about 30-40% more) or a single axis solar tracker (about 6-7% more).

REFERENCES

Bawa, D. and C.Y. Patil, 2013. Fuzzy control based solar tracker using Arduino UNO. Intl. J. Eng. Innovative Technol., 2: 179-187.

Bista, D., 2016. Understanding and design of an Arduino-based PID controller. MSc Thesis, VirginiaCommonwealth University, Richmond, Virginia.

Datta, N., M.N. Ahmed, R. Liya, N. Zaman and B.B. Pathik, 2014. Efficiency improvement of a solar power plant using combine cycle: An experimental study on a miniaturized solar power station. Proceedings of the 6th International Conference on Information Technology and Electrical Engineering (ICITEE'14), October 7-8, 2014, IEEE, Yogyakarta, Indonesia, ISBN:978-1-4799-5302-8, pp: 1-5.

Firoozian, R., 2014. Electrical DC Servo Motors. In: Servo Motors and Industrial Control Theory, Firoozian, R. (Ed.). Springer, Cham, Switzerland, ISBN: 978-3-319-07274-6, pp: 65-90.

Gastelo-Roque, J.A. and A. Morales-Acevedo, 2017. Design of a photovoltaic system using thermoelectric Peltier cooling for vaccines refrigeration. Proceedings of the 2017 IEEE MIT Conference on Undergraduate Research Technology (URTC), November 3-5, 2017, IEEE, Cambridge, Massachusetts, ISBN: 978-1-5386-2535-4, pp: 1-4.

Heperkan, H.A., 2017. Efficient use of energy in the industry. Proceedings of the Conference on Towards 100% Renewable Energy, February 22, 2017, Springer, Cham, Switzerland, ISBN:978-3-319-45658-4, pp: 3-16.

Jazayeri, M., S. Uysal and K. Jazayeri, 2013. Experimental analysis of effects of installation alignment and solar insolation on power generation by solar panels. Proceedings of the 2013 IEEE Conference on Global Humanitarian Technology (GHTC), October 20-23, 2013, IEEE, San Jose, California, ISBN: 978-1-4799-2401-1, pp: 35-40.

Kong, T., H. Wang, X. Liu, J. Yu and C. Wang, 2017. Improving the efficiency of bulk heterojunction polymer solar cells via binary-solvent treatment. IEEE. J. Photovoltaics, 7: 214-220.

Li, Y., 2012. Three dimensional solar cells based on optical confinement geometries. Ph.D Thesis, Wake Forest University, Winston-Salem, North Carolina, USA.

Margolis, M., 2011. Getting Input from Sensors. In: Arduino Cookbook: Recipes to Begin, Expand and Enhance your Projects, Margolis, M. (Ed.). O'Reilly Media, Inc., Sebastopol, California, USA., ISBN:978-1-449-31387-6, pp: 181-123.

Melgar, E.R., C.C. Diez and P. Jaworski, 2012. Arduino Basics. In: Arduino and Kinect Projects: Design, Build, Blow their Minds, Melgar, E.R., C.C. Diez and P. Jaworski (Eds.). Apress, New York, USA., ISBN:978-1-4302-4167-6, pp: 1-22.

Mousazadeh, H., A. Keyhani, A. Javadi, H. Mobli, K. Abrinia and A. Sharifi, 2009. A review of principle and sun-tracking methods for maximizing solar systems output. Renew. Sustainable Energy Rev., 13: 1800-1818.

Muneer, T., M. Asif and S. Munawwar, 2005. Sustainable production of solar electricity with particular reference to the Indian economy. Renewable Sustainable Energy Rev., 9: 444-473.

Nakamura, M., S. Goto and N. Kyura, 2004. 2 Mathematical Model Construction of a Mechatronic Servo System. In: Mechatronic Servo System Control, Nakamura, M., N. Kyura and S. Goto (Eds.). Springer, Berlin, Germany, ISBN:978-3-540-21096-2, pp: 17-52.

Parmar, S.J., M.S. Zala, I.S. Thaker and K.M. Solanki, 2017. Design and development of stepper motor position control using Arduino mega 2560. Intl. J. Sci. Technol. Eng., 3: 77-82.

Sahni, A., 2015. Energy-efficient solar model improvement using motor calibration preference. MSc Thesis, Chemnitz University of Technology, Chemnitz, Germany.

Sulaiman, M.A.B., 2014. Development of sensor less solar tracking system. BSc Thesis, Universiti Teknikal Malaysia Melaka, Durian Tunggal, Malaysia.

Yu, D., H. Ni, K. Zhao, S.Q. Zhao and S.L. Da *et al*., 2011. Effects of oxygen stoichiometry on the photovoltaic properties of $La_{0.4}Ca_{0.6}MnO_3$-ä epitaxial films grown on miscut MgO substrates. Proceedings of the 2011 International Conference on Electronic and Mechanical Engineering and Information Technology (EMEIT'11) Vol. 2, August 12-14, 2011, IEEE, Harbin, China, ISBN:978-1-61284-087-1, pp: 725-728.