IJournals: International Journal of Software & Hardware Research in Engineering
ISSN-2347-4890
Volume 4 Issue 6 June, 2016

Study and Design of a Smart Microcontroller based Solar Tracking System

Mohammed AbdALLA Adam Elmaleeh[1], Hiba M. E. Khatab[2]

Faculty of Engineering, Alneelain University, Khartoum, Sudan[1]; Sharjah, UAE[2]

maleeho@hotmail.com[1];hibaelx@hotmail.com[2]

ABSTRACT

The sun is responsible for all of the earth energy. Solar energy is most commonly collected by using solar cells. Solar cells are used to generate the electrical energy required to supply the electrical appliances and equipment [1]. Due to the lack of energy sources and the high demand of electrical energy all over the world, the search of energy sources plays an important role in the development. It is found that the renewable energy source is the best choice. This study intends to design and implement a smart microcontroller based solar tracker system. It rotates the payload toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices. In flat-panel photovoltaic applications, trackers are used to minimize the angle of incidence between the incoming sunlight and a photovoltaic panel. This increases the amount of energy produced from a fixed amount of installed power generating capacity. As the sun moves across the sky a dedicated electric actuator system automatically controls the solar panels to follow the sun direction maintaining the optimum angle in order to obtain the maximum sunlight to strike the panels. The experiments conducted on the proposed tracking system in suburb area presented reasonable amount of electric energy that could be used throughout the day.

Keywords: Solar energy, solar cells, actuators, electrical appliances, photovoltaic, payload, microcontroller, solar tracker, suburb areas.

1. INTRODUCTION

Solar energy is most commonly collected by using solar cells. Of course solar energy can be used to heat or light up a room by simply having well placed windows and skylights. It can also be used to dry clothes when exposed to sun. Light solar energy is created by light and heat which is emitted by the sun in the form of electromagnetic radiation. In today technologies the sun radiations could be captured and utilized into solar energy. Generally solar energy could be converted into electrical energy by two ways. The first is the solar thermal, where the water is traditionally heated by the sun in order to be used in the large energy plants. The second mechanism used to convert sun light into electrical energy is the solar cells. These cells are divided into bulk or wafer based, the bulk type usually employing silicon and thin film which uses a variety of metals. It could be easily manufactured and installed. However the wafer based cells requires more square footage to function properly [1-3].

1.1 The Solar Panel

The solar panel is composed of solar cells that collect solar radiation and transform it into electrical energy. The electrical current supplied by a solar panel varies proportionally to the solar radiation. This will vary according to climatological conditions, the hour of the day, and the time of the year. This part of the system is sometimes referred to as a solar module or photovoltaic generator. Solar cells can be combined into larger units called "modules", these modules can again be connected together to form arrays. Solar panel arrays can be made by connecting a set of panels in series and/or parallel in order to provide the necessary energy for a given load. Figure 1 is an example of solar panel. Connecting the panel's series allows a solar array to run at a higher voltage and connecting the panels parallel allows a solar array to produce more power while maintaining the same voltage as he individual panels [4-7].

1.2 Solar Panels operation principle

The basic element of solar panels is pure silicon. When stripped of impurities, silicon makes an ideal neutral platform for transmission of electrons. In silicon's natural state, it carries four electrons, but has room for eight. Therefore silicon has room for four more electrons. If a silicon atom comes in contact with another silicon atom, each receives the other atom's four electrons. Eight electrons satisfy the atoms' needs, this creates a strong bond, but there is no positive or negative charge. This material is used on the plates of solar panels. Combining silicon with other elements that have a positive or negative charge can also create solar panels [4-7].

For example, phosphorus has five electrons to offer to other atoms. If silicon and phosphorus are combined chemically, the results are a stable eight electrons with an additional free electron. The silicon does not need the free electron, but it cannot leave because it is bonded to the other phosphorous atom. Therefore, this silicon and phosphorus plate is considered to be negatively charged. A positive charge must also be created in order for electricity to flow. Combining silicon with an element such as boron, which only has three electrons to offer, creates a positive charge. A silicon and boron plate still has one spot available for another electron. Therefore, the plate has a positive charge. The two plates are sandwiched together to make solar panels, with conductive wires running between them [8].

Photons bombard the silicon/phosphorus atoms when the negative plates of solar cells are pointed at the sun. Eventually, the 9th electron is knocked off the outer ring. Since the positive silicon/boron plate draws it into the open spot on its own outer band, this electron does not remain free for long. As the sun's photons break off more electrons, electricity is then generated. When all of the conductive wires draw the free electrons away from the plates, there is enough electricity to power low amperage motors or other electronics, although the electricity generated by one solar cell is not very impressive by itself. When electrons are not used or lost to the air they are returned to the negative plate and the entire process begins again [8].

2. SOLAR TRACKER

The solar tracker is a device that orients a payload toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices. In flat-panel photovoltaic (PV) applications, trackers are used to minimize the angle of incidence between the incoming sunlight and a photovoltaicpanel. This increases the amount of energy produced from a fixed amount of installed power generating capacity [9-10].

Solar tracking is an obvious way to improve the efficiency of solar power plants. As the sun moves across the sky an electric actuator system aromatically controls the solar panels to follow the sun direction maintain the optimum angle in order to make the most of the sunbeams. This ensures the maximum amount of the sun light sunlight to strikes the panels throughout the day [10].

The generating of electricity is a major concern in most parts of the world. In Sudan the rural areas do not have enough electrical power sources. Some solar systems were used to supply energy; however it is found that the solar cell has some disadvantages that restrict the spread of electrical energy. Some of these disadvantages are in the intermittent i.e. the solar energy is only available when the sun is shining and means the low efficiency of energy production. Also it requires large areas of land with large solar cells which is really costive.

The proposed solar tracking system automatically tracks the sun movement to continuously generate the electricity. It uses few solar cells and a dedicated electronic circuit to move the solar cells in the direction of the sun. This allows the sun rays to continuously incident on the solar cells to maintain the availability of the electrical energy. Figure 1 shows the flow chart of the proposed solar tracking system.

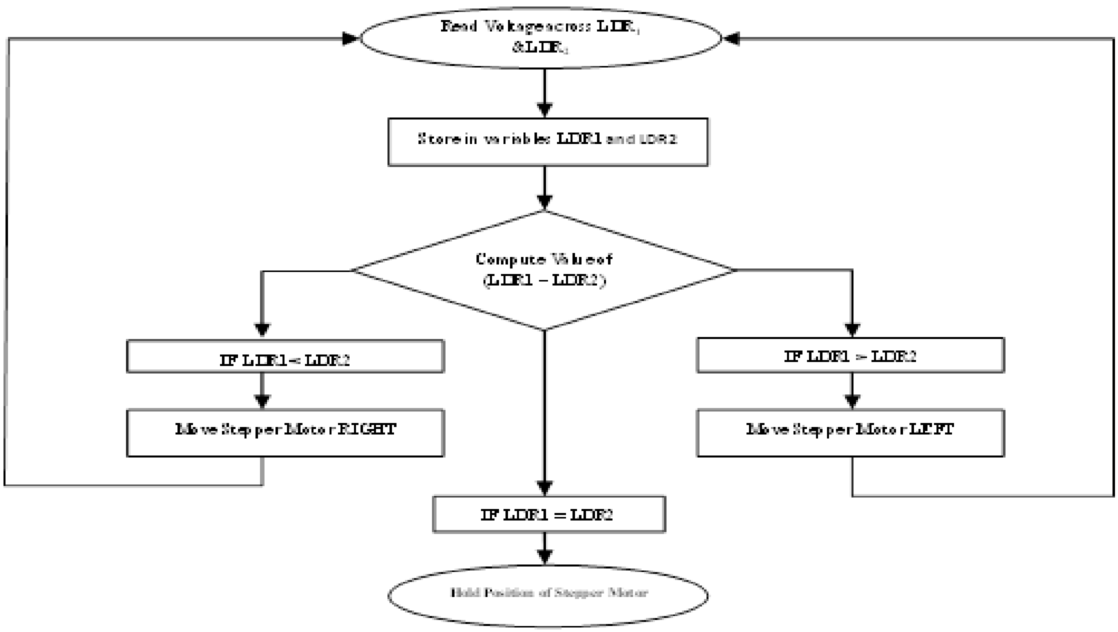


Fig1: Flowchart of the Solar Tracker

The stepper motor used in this research is capable of stepping 7.5° per. This means in 48 steps the motor complete exactly 360°, or one complete revolution. The motor steps each time its field coil switches in a certain sequence. The motor has 2 field coils arranged perpendicular to each other, with each coil containing a center tap. The center tap allows half the coil to be energized at a time which in turn allows the 2 coils to function as 4 coils separately which allows 2 poles in the 2 perpendicular directions. The stepper motor is used to move the solar cell to the required direction.

The motor being used in this study is from Minibreak Electronics (PM 42S – 048). It has a permanent magnet with 2 phase stepper supplied by 18 volts battery. Each coil in the motor is connected to a diode to avoid the effect of the back electromotive force.

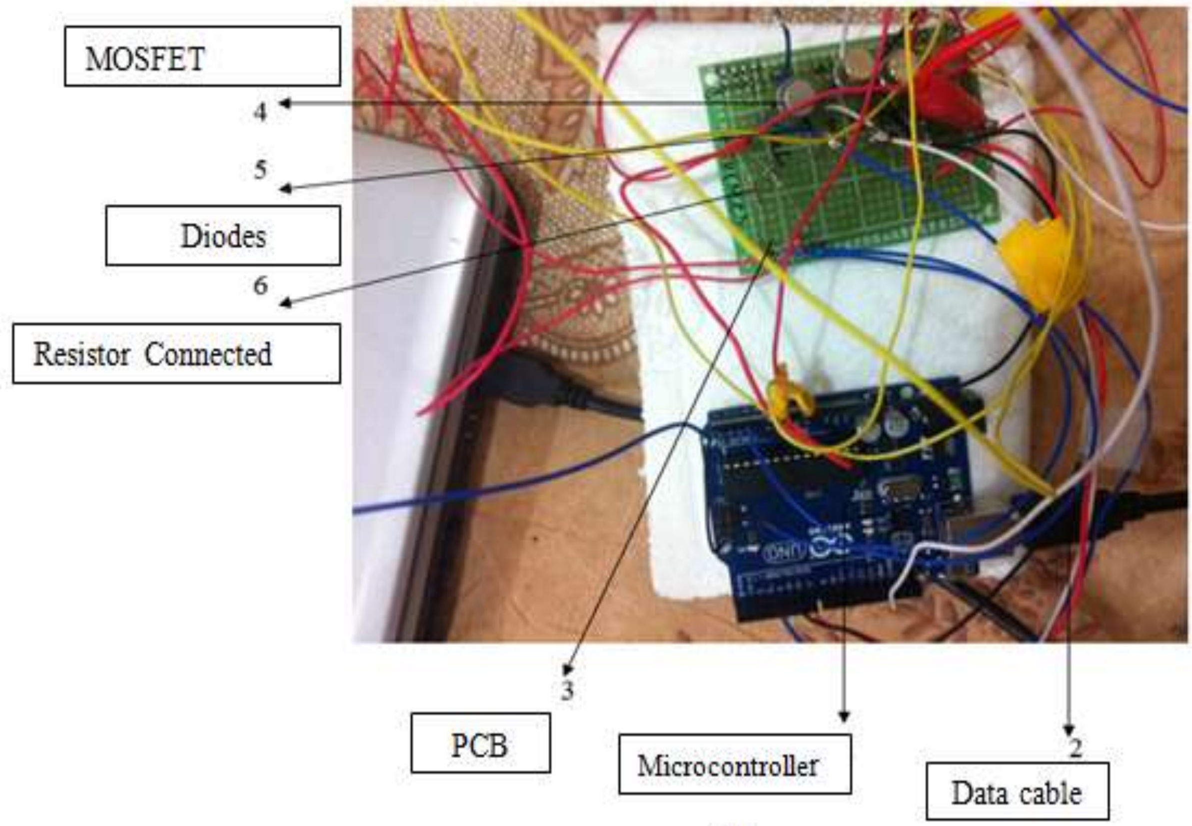
The high power BJT transistor is used as a switch to controls the current flow through coils. The coils outputs are connected to the microcontroller which in turns reads and stores the voltages of LDR1 and LDR2 to control the movement of the motor as follows:

First step the microcontroller read voltage across LDR1& LDR2 and stored in variables.

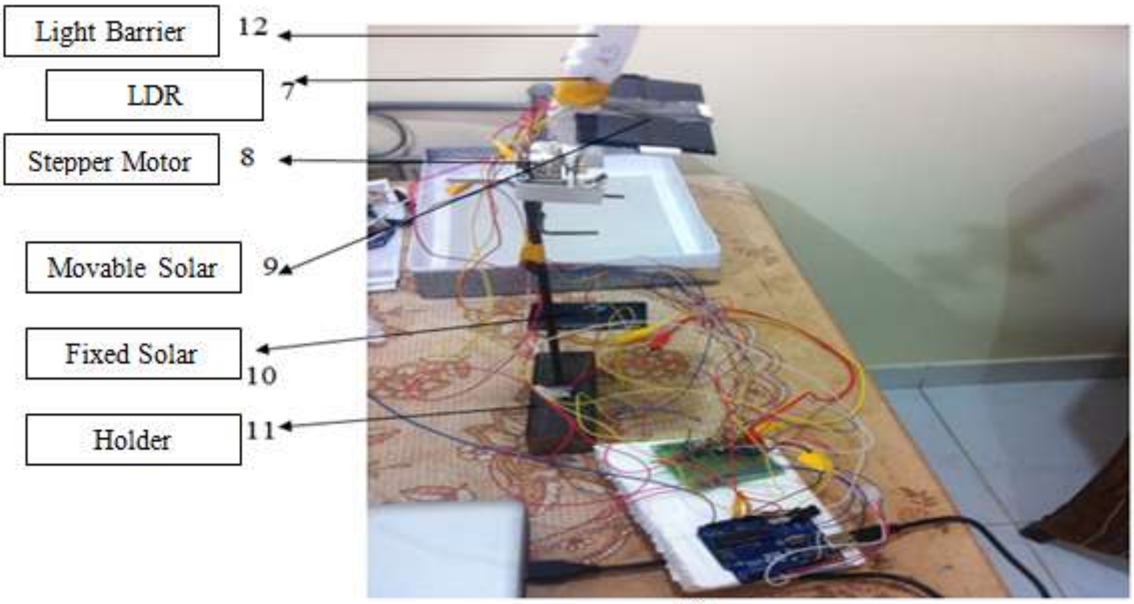
Second step the microcontroller compare the value of the voltage of LDR1& LDR2.

- If LDR1> LDR2 the microcontroller gives the order to the stepper motor to move left (this is the direction of the LDR1), after that the micro controller will start again the first step.
- If LDR1< LDR2 the microcontroller gives the order to the stepper motor to move right (this is the direction of the LDR2), after that the micro controller will start again the first step.
- If LDR1=LDR2 the microcontroller give the order to the stepper motor to hold position of the stepper motor, after that the micro controller will start again the first step.

The circuit shown in Figure 2 represents the proposed solar tracking system. Several tests were carried under various operating conditions.



(a)



(b)

Fig 2: (a). (b). The proposed Setup of the Proposed Solar Tracker

3. EXPERIMENTAL RESULTS

Several measures were carried out in the tracing system shown in Figure2. Different solar cells were used (20 W, 3W, 1W). Figures 3 to Figure 13 showsamples of the results obtained at various operating conditions when the cells are active and inactive.

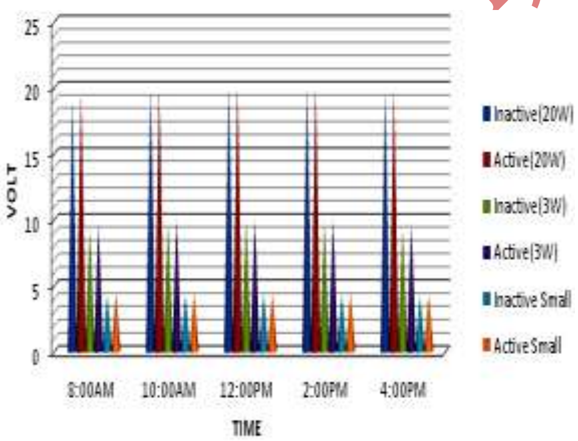


Fig3: Test1: Output voltages generated from the three cells at different time in a day

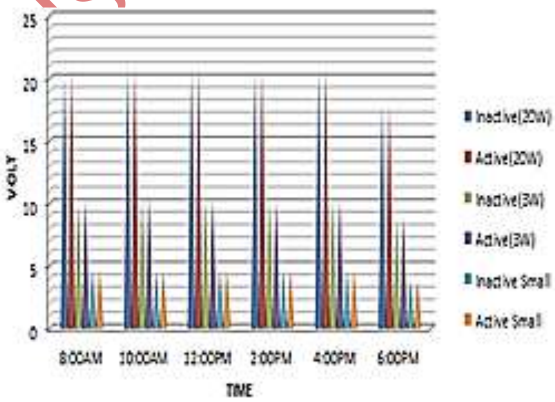


Fig4: Test2: Output voltages generated from the three cells at different time in a day

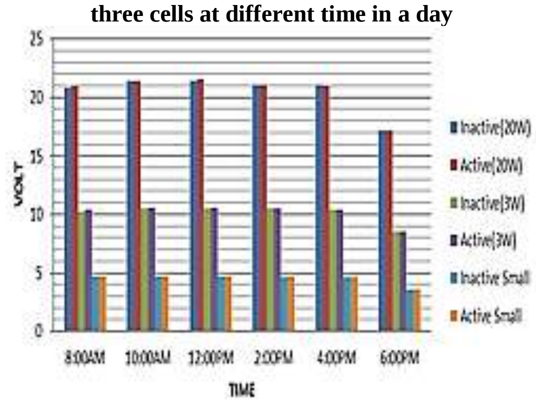


Fig5: Test3: Output voltages generated from the three cells at different time in a day

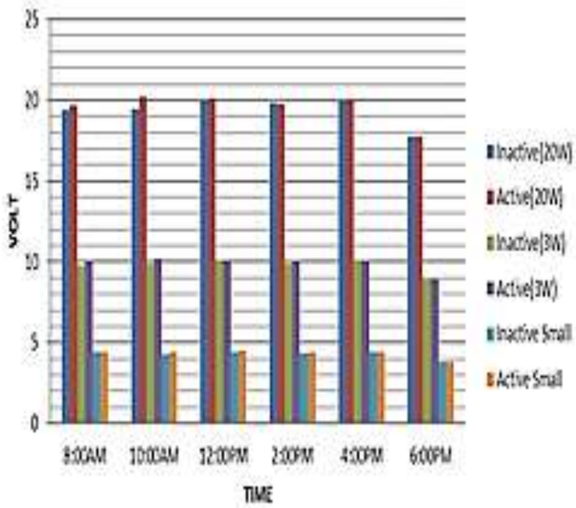


Fig6: Test4.Voltages generated from the three cells at different time in a day

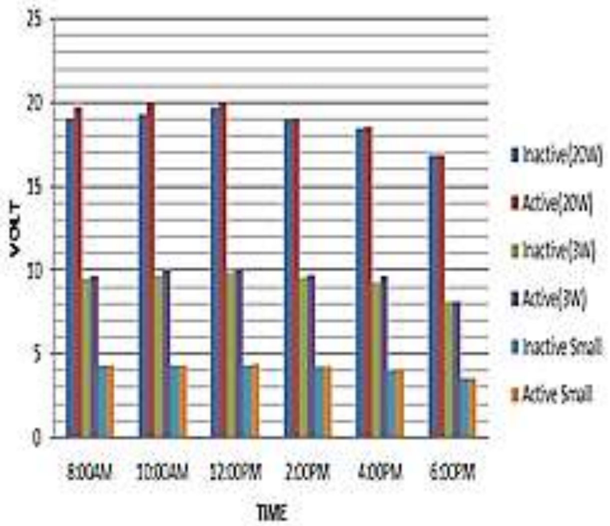
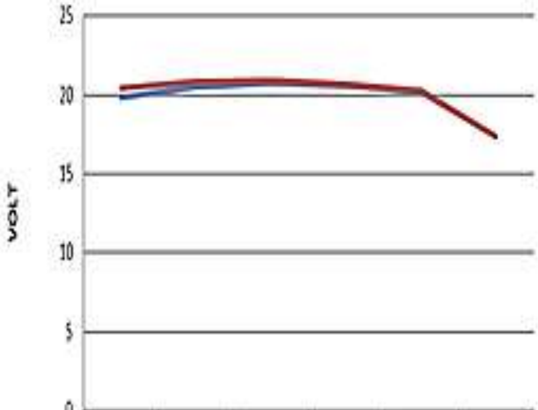


Fig7: Test5. Voltage generated from the three cells at different time in a day



	8:00AM	10:00AM	12:00PM	2:00PM	4:00PM	6:00PM
Inactive	19.814	20.507	20.728	20.542	20.141	17.334
Active	20.416	20.839	20.879	20.628	20.248	17.338

Fig8. Voltages generated from the 20 W Cells

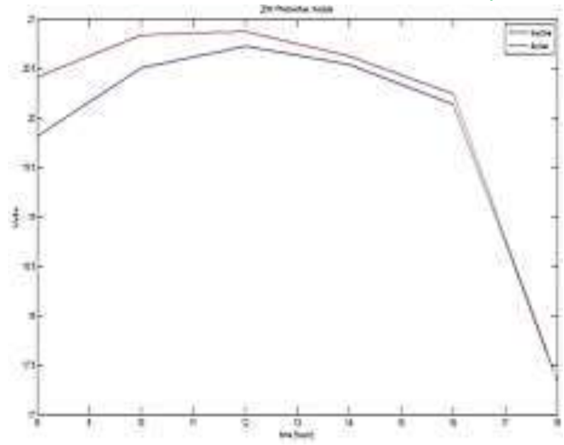
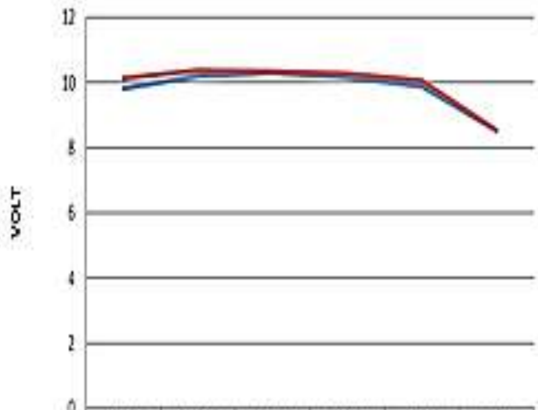


Fig9: Voltages generated from the 20 W Cell Using Mat Lap



	8:00AM	10:00AM	12:00PM	2:00PM	4:00PM	6:00PM
Inactive	9.809	10.194	10.296	10.173	9.91	8.545
Active	10.135	10.396	10.361	10.282	10.056	8.549

Fig10. Voltages generated from the 3 W Cell

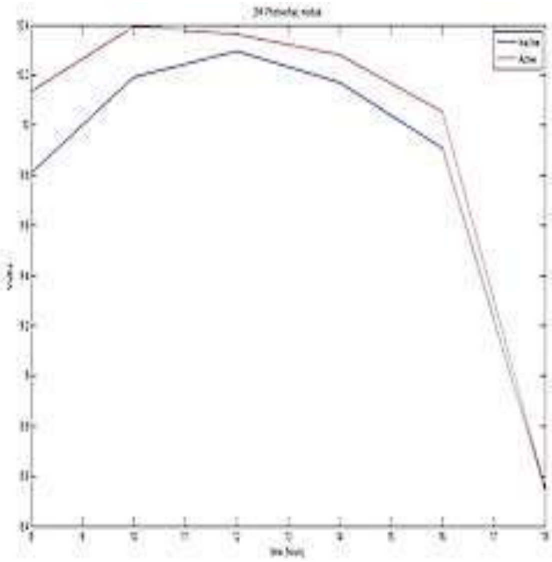
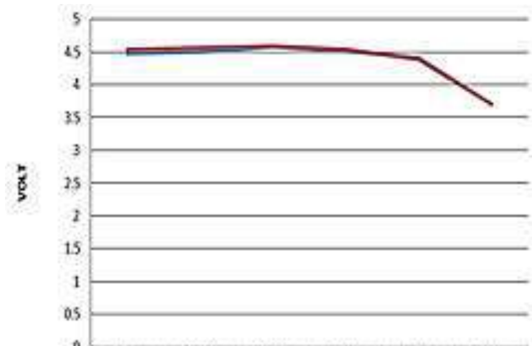


Fig11. Voltages generated from the 3 W Cells using Mat Lab

ISSN-2347-4890
Volume 4 Issue 6 June, 2016



	8:00AM	10:00AM	12:00PM	2:00PM	4:00PM	6:00PM
Inactive	4.47	4.502	4.571667	4.508	4.407	3.7
Active	4.536	4.567	4.592	4.536	4.388	3.7

Fig12. Voltages generated from the small Cell

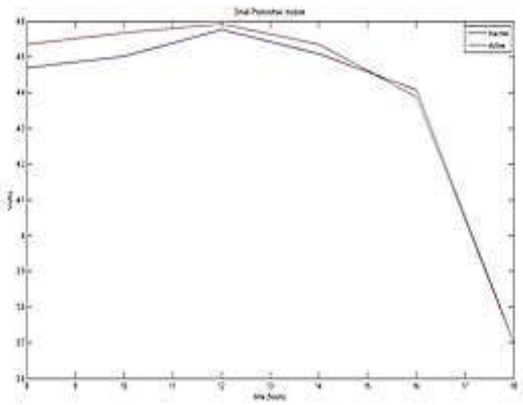


Fig13. Voltage generated from the small Cell using Mat Lap

4. DISCUSION

The Measurements were carried out for the voltage generated from the three solar cells of different sizes in many days. The measurements for each cell were performed into stationary and tracking mode every two hours from early morning till evening.

The results shown in the previous Figures represent the readings obtained for the two modes named active (tracking) and inactive (stationary). They show that the voltage generated from the tracking system is larger than that generated from fixed calls.

When reading the average of the voltages generated in ten days for the three cells using Mat Lab: Fig9, 11,13: for the tracking and fixed modes; It showed that the average power generated from the tracking system is higher than that of the fixed cells.

It is also found that the average voltages generated in ten for each of three cells (20W, 3W and 1W) are20.728V, 10.296V and 4.577Vrespectively.

It is observed that for the optimum energy capture the collector must be perpendicular to the sun's rays when the angle of incidence is 90°. For a flat plate on the ground this occurs only when the sun is directly overhead. This condition could be obtained by implementing the proposed tracking system

5. REFERENCES

1. Peter Gevorkian, Sustainable energy systems engineering, The McGraw-Hill Companies, Inc, 2007
2. Earthscan, Grid-connected solar electric system, Global Sustainable Energy Solutions Pty Ltd, 2012.
3. Gavin D.J. Harper, Solar Energy Projects for the Evil Genius, The McGraw-Hill Companies, Inc, 2007.
4. Frederik c. krebs, Polymeric solar cells, DEStech Publications, Inc, 2010.
5. Dan Chiras, Solar electricity basics, Dan Chiras, 2010.
6. Eric Smith, Diy Solar Project, by, Creative Publishing international, Inc, 2011.
7. U.A.Bakshi and V.U. Bakshi, Electrical engineering and control system, Technical Publications Pune, 2008.
8. Muhammad H. Rash, Power Electronic handbook third edition, Elsevier lnc, 2011.
9. Soteris A. Kalogirou, Solar energy engineering processes and system, Elsevier lnc, 2009.
10. Deutsche GesellschaftFürSonnenenergie (Dgs), Planning & installing photovoltaic systems, The German Energy Society (Deutsche Gesellschaft fur Sonnenenergie (DGS LV Berlin BRB), 2008.

BIOGRAPHY

Mohammed Elmaleeh received his BSc degree from Gezira University (Sudan), Faculty of Engineering and Technology (Communication and Control Engineering). In 1998 Elmaleeh received his MSc in Electrical and Electronic Engineering, University of Khartoum, Sudan. From 1994 to1998 Mr. Elmaleeh worked as research assistant and researcher in Sudan Atomic Energy Commission. In 1998 Mr. Elmaleeh joined QAPCO (automation department), Qatar. In 2009 Mr. Elmaleeh received his PhD degree in Electrical and Electronic Engineering, University Technology PETRONAS, Malaysia. Currently Elmaleeh works as Associate Professor at the faculty of Engineering, Alneelain University. Dr Elmaleeh published many papers in the field electronic engineering. He supervised many post graduate and undergraduate students in their research projects. Dr Elmaleeh is assigned as a reviewer for several IEEE conferences and international journals. His research interest includes electronic engineering; embedded systems, fiber optics, wireless communication and computer engineering.