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Maximum Power Point Tracking using Light Dependent Resistor and DC motor for Solar Photovoltaic System in Kuwait

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Abstract: In this paper a Maximum Power point (MPP) tracking system is developed using dual-axis DC motor feedback tracking control system. An efficient and accurate DC motor system is used to increase the system efficiency and reduces the solar cell system coast. The suggested automated DC motor control system based on the photovoltaic (PV) modules operated with the µ-microcontroller. This servo system will track the sun rays in order to get MPP during the day using direct radiation. A photometric cell is used to sensor the direct sun radiation and to feed a signal to the µ microcontroller and then select the DC motor mechanism to deliver optimum energy. The proposed system is demonstrated through simulation results. Finally, using the proposed system based on microcontroller, the system will be more efficient, minimum cost, and maximum power transfer is obtained.

Keywords: DC moto, LDR , MPPT, µ-controller, Photovoltic

I. INTRODUCTION

PV cells are made of semiconductor materials, such as silicon. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current and generate electric power. This electric power can then be used to power a load [1-3]. A PV cell can either be circular or square in construction. The power that one module can produce is not sufficient to meet the requirements of home or business. Most PV arrays use an inverter to convert the DC power into alternating current that can supply loads such as motors, lights etc. The modules in a PV array are usually first connected in series to obtain the desired voltages; the individual modules are then connected in parallel to allow the system to produce more current [4].

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The different PV system configurations are displayed in Figure 1. Photovoltaic (PV) cells are basically transducers that directly convert solar energy into electrical energy.
The physics behind such cells is similar to that of the basic p-n junction [6, 7]. It follows that an appropriate model of the PV cell should be able to predict its electrical characteristics under different irradiance and temperature levels.

Most of the widely used models of PV cells follow the equivalent circuit approach where a PV cell is represented by an equivalent circuit that consists of one or two diodes [6, 8, 9].

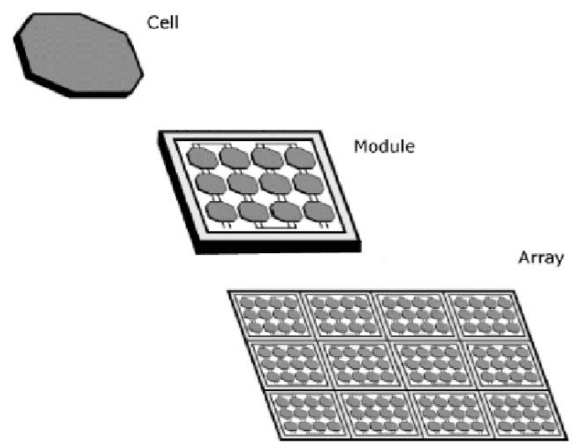

Figure 1: Photovoltaic systems [5]

A simple and popular model of the PV cell is the one representing it with an equivalent circuit consisting of a single diode [10-12]. In such a model, the ohmic losses can be taken into consideration by including a series resistance and/or a shunt resistance. When both the series and shunt resistances are considered, the model of the PV cell, which is shown in Figure 2 (a), requires computation of five parameters in order to establish the current-voltage relationship that characterizes the cell [13]. The number of parameters becomes four when only the series resistance is taken into consideration [5, 14-17]. The four parameters model is shown in Figure 2 (b). An attractive feature of the aforementioned models is that most of the calculations only rely on the data provided by the manufacturer. Another important feature is the fact that these models can be used in representing a single cell, a module of connected cells, or even an array of modules. The single diode model is suitable for system-level designs. However, experiments requiring high accuracy at the expense of complication can use more complicated models such as the two diodes model [11, 18].

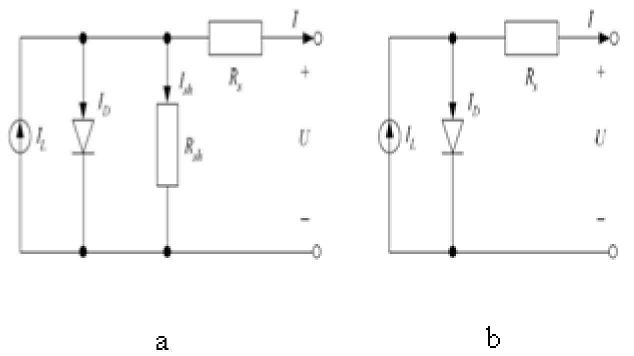

Figure 2: The equivalent circuit in single diode PV models. (a) Five parameters model. (b) Four parameters model.

Energy needs are growing in many instances to aid and fulfil the boom of world need. Many nevertheless depend heavily on the natural gas, coal and crude oil as the major power resources. However, these fossil fuels which can be categorized as non-renewable strength are finite and will burn up eventually [19, 20]. As they are depleting, it will become greater highly priced and international locations will be competing for the reserves that are left. The photo voltaic electricity had been used dated again because seventh century B.C. Throughout the century the method of harnessing photo voltaic power had advanced such as having photo voltaic thermal energy, photo voltaic tower and photovoltaic technologies. Solar electricity is the most promising renewable energy as it is naturally handy and clean derived from the sun. Solar energy can be produced silently with minimal maintenance, no pollution and no depletion of resources. There are two techniques to produce electrical energy from the solar which are via concentrating solar thermal or through a photovoltaic (PV) cell [21-23]. The most frequent way use for generating electrical energy is photovoltaic technology which will convert mild energy (photons) at once into electrical energy (voltage) via the aids of photo voltaic cell made up of silicon. It is extensively installed in the residential buildings usually at rooftop and open area the place availability of daylight is high. However, the primary challenges of solar strength application are decrease electricity density and role exchange of sun. Thus it inflicting lengthy length of time to attain higher energy conversion to electricity. Consequently, exploring excessive efficiency photo voltaic tracking technological know-how is blooming as it is seen as necessary and realistic method to achieve most excellent effectivity for solar-to-electric conversion. Just like in different international locations in the world, the need of power in the developing use such as Kuwait turns into foremost concern. The essential dealer of electricity in Kuwait is come from oil and gas[24, 25]. Nowadays, the use of oil and fuel is viewed as the essential motive of the carbon emission which will lead to the greenhouse effect. Apart from that, the oil and gas assets are getting lower and hold decreasing. In such systems, a number of inputs are transferred to a microcontroller from the sensors through the feedback which detect relevant parameters induced by the sun, manipulated in the microcontroller and then yield desired position.

II. SYSTEM ARCHITECTURE: SUN POWERED TRACKER COMPONENT DESIGN

There are total 3 conceptual designs generated and will explain in detail as the following. First of all, the dark blue color represents the stand base. The orange is the base for the PV panel and grey color represent the PV panel. In the Figure 3(a) is one of the conceptual designs which are "Rigid Base" concept design. In this conceptual design, the base is perpendicular to upward. Next, the second conceptual design is shown in the Figure 3 (b) This is a “Single Axis Base” concept design which is the base can rotate only single axis. The base can only rotate up and down for the whole base with PV panel. After that, the third concept design is shown on the Figure 3(c) which is more different with the previous conceptual design. This conceptual design is built up by "Dual Axis Base" which the PV panel can move up and down, left and right. This able PV panel to rotate 360 degrees and always perpendicular to the sunlight to ensure maximize the solar energy harvesting process. Finally, all the 3(d) different conceptual designs are generated and drawn by using the Solidworks software. The next step will be the selected method to finalize the most suitable hybrid harvesting system design in the design evaluation.

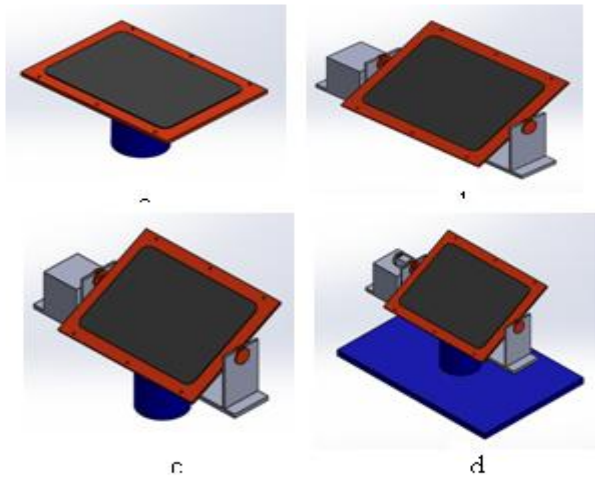

Figure 3: Conceptual Design of Solar Tracking System

Figure 4 shows that the exploded drawing of the dual axis solar tracking system. All the structure and design can be viewed in detail based on the drawing

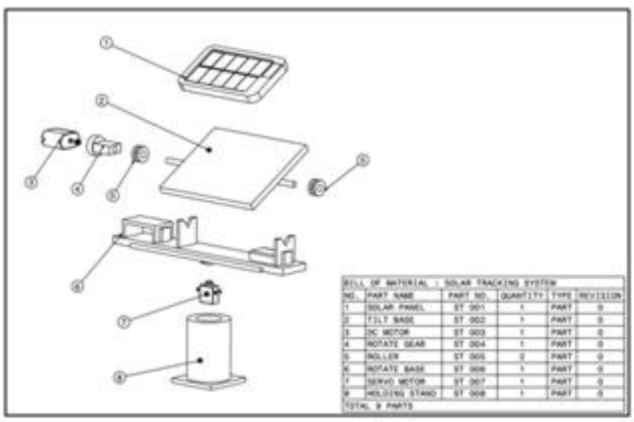

Figure 4: The Exploded Drawing for Solar Tracking System

Firstly, the 6 units of the LDR on top of the tilt base need identify the name as shown in the programming below. All these 6 units sense values will give a name to indicate the position of the LDR. There are 3 units for left hand side and 3 units on the right-hand side. The name on the horizontal will differentiate by top (Top), middle (Mid) and bottom (Btm). All units of LDRs total arrangement as shown in Figure 5.

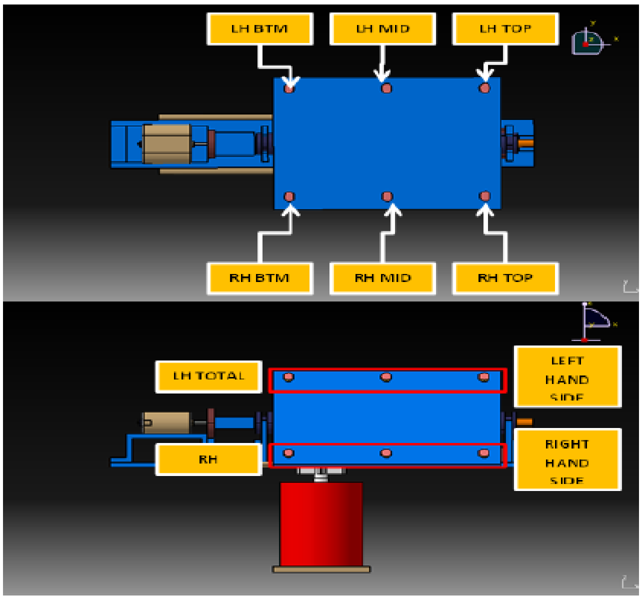

Figure 5: The Arrangement of LDR

In prototype of solar tracking system, the DC motor is controlled for the tilt to ensure left hand total value and right-hand total value different less than 200ohm. To achieve less than this reading, the DC motor will turn to left hand side or right side until achieving a steady mode for the tilt base [24]. The movement of the DC motor as shown in the Figure 6.

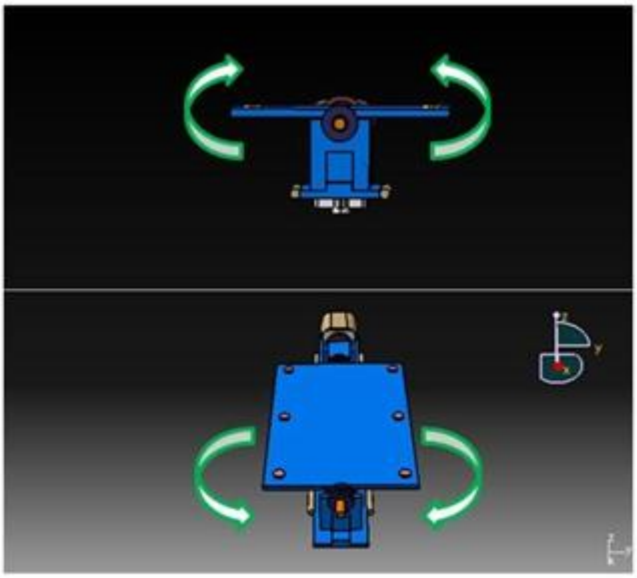

Figure 6: The Rotation for DC Motor

III. EXPERIMENTAL SETUP: SUN POWERED TRACKER COMPONENT DESIGN

Setup has two parts (i) Electronic sensors (ii) Mechanical mechanism.

Mechanical mechanism is managed by using LDR based sensors. A Detailed description is given below in Figure 7. Electronic Sensor's Circuit: In this setup two comparable circuits have been used. Each circuit has two LDR sensors as proven in Figure three Circuit 1 and circuit 2 are comparable to every other. A single circuit has many semiconductor elements which are two LDR sensors (10K at full illumination, limitless at total darkness), 4 transistors (TIP 31 C, TIP 32 C), 4 Diodes (1N4007), two registers (10K, 33K), two presets (P1=220K, P2=22K), 1 IC (IC 324), 1 DC Motor. The circuit is fabricated as proven in Figure three Arduino is required for programming and manage purpose.

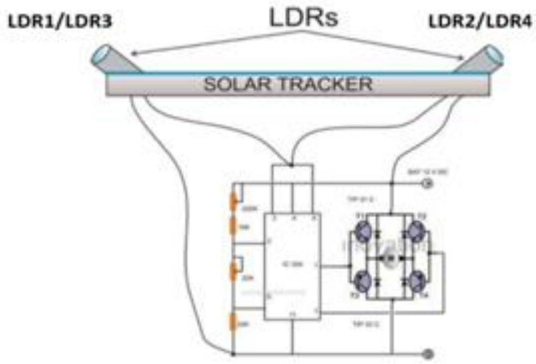

Figure 7: Microcontroller Tracking Circuit

A. PV Position Control System

A PV position control system illustrated in Figure 8 used for orienting a solar photovoltaic panel toward the sun. PV position control system can increase the effectiveness of such system over any fixed position. A high degree of accuracy of the PV position control system is to ensure that the concentrated sunlight is directed precisely to the PV panel. The PV panel is adjusted according to the difference between the desired and the actual panel position. The microcontroller output which is the actuating signal is applied to the driving circuit which drives the servomotor in order to maintain the panel in the desired position that enable the photo sensors to receives a maximum power.

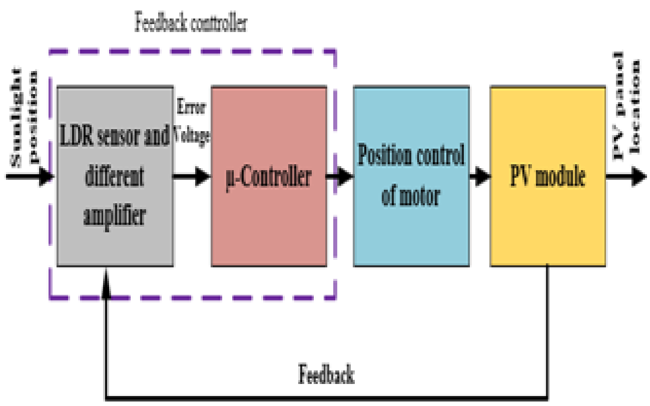

Figure 8: PV Panel Position Control System

B. MICROCONTROLLER TRACKING SYSTEM

Solar trackers are constructed using a mix of hardware modules and Software control systems. The set-up involves micro-controller circuits, sensors, comparators, generators and electrical motors. In general, stepper-engines or servo-engines are typically used. The platform on which PV cells are installed is assembled and programmed. Any of these elements are replaced by the Arduino board concept discussed in this report. The scheme of how the monitoring device works is shown in Figure 9. The device has been developed using an electric power supply machine, an Arduino board and a servo motor and an LDR, that can be used as light sensors to detect light from the sun. In order to attain the MPP the device is powered in contrast to the heat. Therefore, the solar cells retain their perpendicular (90 degree) position to the sky light, while the tracking unit bends towards the perpendicular. The PV Location Control (LDR) is the electrically operated system for positioning the solar panel perpendicular to the horizon. By the the time of radiant absorption, the monitoring device increases the performance of the solar panel. The sun's monitoring with the greatest level of accuracy means that the solar panel accurately receives concentrated radiant radiation. The micro-controller is the decision-maker working with a powertrain, light sensors and motors to guide the support system of the solar panel to the light of the sun. The light from the Sun is sensed by the LDR and the compartment is connected. The LDRs are placed opposite each other in the column. The four (4) LDRs are used in a solar multi-axis tracking device, each pair being located in an opposite direction. The voltages of the four (4) LDRs are equal if the solar panel is located perpendicularly. The unequal voltage produced by the sensors leads to a new location of the microcontroller, consistent with the sun 's motion. Figure 9 illustrates how the sensors are mounted on the solar tracking device with different axes.

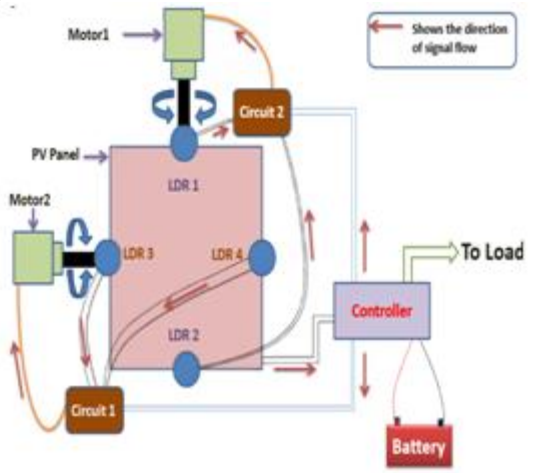

Figure 9: Position of LDR

LDR sensors are hooked up at the center of the side edges of the PV panel as proven in Figure two If there is any depth distinction in between LDR3 & LDR4 or LDR1 & LDR2 then a signal produces. This sign reaches to the manage gadget (circuit1/circuit2) and is evaluated there. Then required education signal reaches to the motor (motor2/motor1) which is connected to mechanism and the motor rotates the PV panel. LDR1 and LDR2 ship the indications to circuit1 and LDR3 and LDR4 send the alerts to circuit2. Circuit1 and circuit2 send the signals to motor2 and motor1 respectively, and also operate them. The panel rotates in accordance to this manage signal and the action of the PV panel stops at the role where it without lengthen faces the Sun as shown in Figure 10.

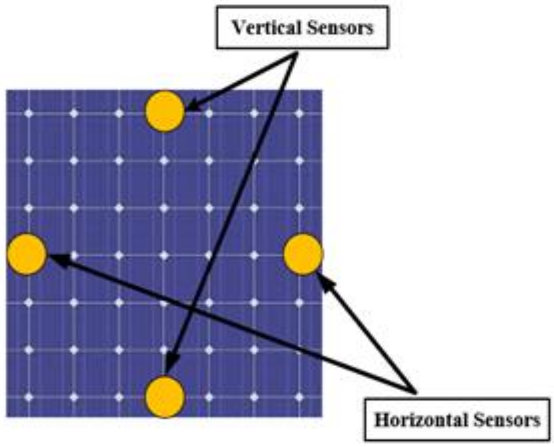

Figure 10: Block diagram of the setup

IV. RESULTS AND DISCUSSION

The experiment is carried out based on solar panel, which has been used to generate maximum power. This sun temperature has been measured and a constant irradiation of approximately 1000W/m2. The most extreme control of 4.64W is gotten at a voltage of 16V. The readings are arranged, and the I-V and P-V bends are plotted as appeared in Figure 11 and Figure12 distinctly.

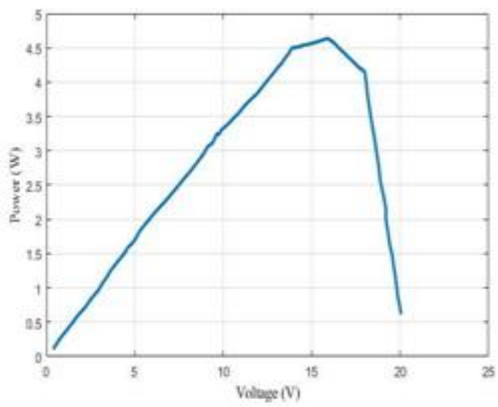

Figure 11: PV curve of solar panel

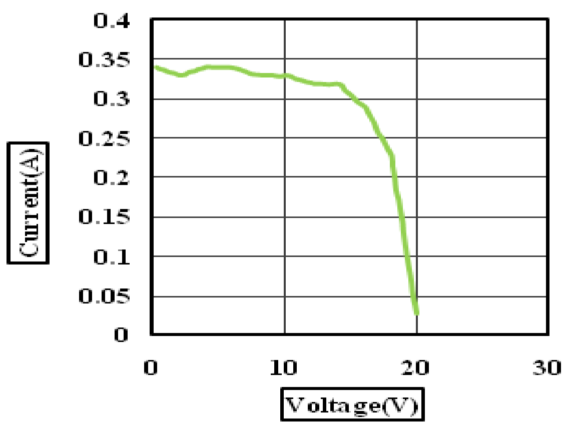

Figure 12: IV curve of solar panel

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While the attempt comes almost conducted for one month from 1 to 30 June 2018 have showed up in Figure 13, and 14, where the natural conditions counting temperature, sun oriented light escalated, and wind speed are nearly the same as the past. The normal control increment of the framework is 47.16% compared to the settled one. It implies amid the dry season that the model can move forward the control effectiveness over 47%, particularly in Kuwait which may be a tropical nation with two seasons.

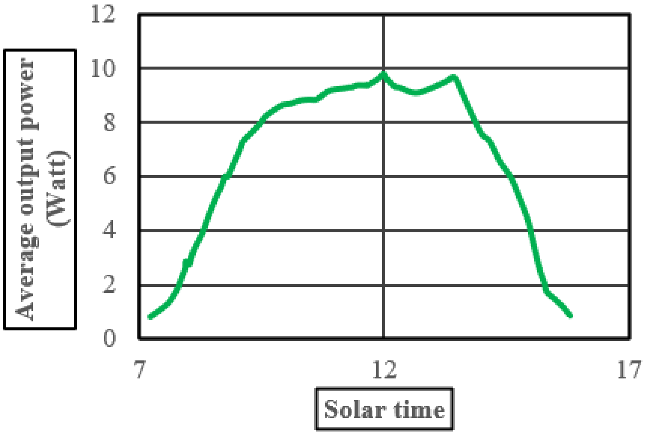

Figure 13: Normal control yield of tracking PV boards for one- month

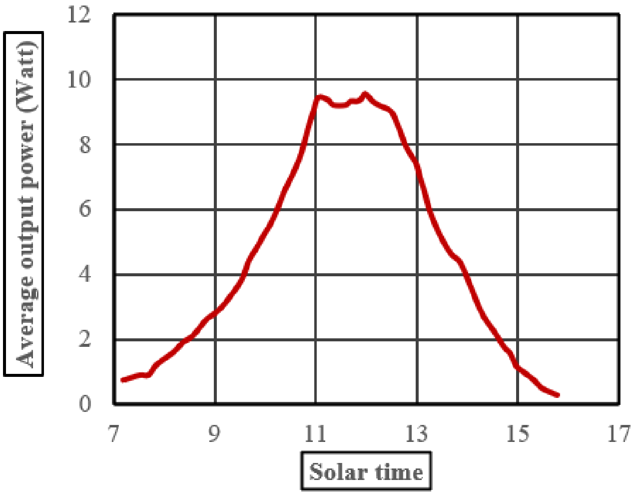

Figure 14: Normal control yield of fix PV boards for one- month

Figure 15 and 16 illustrates the comparison of yield vitality created by two distinctive frameworks for one-day i.e beginning from 07.00 AM until 04.00 PM, the information are taken each 30 minutes, hereas the sky is evident with greatest brightening concentrated, discuss temperature and the normal wind speed are 110 600 lux, 36.3°C and 2 m/s, separately. Based on the explore comes about, it can be known that the biggest control increment accomplished by the sun powered following framework is 192.5% of the settled PV board which happened at 09.00 AM. This appears that the radiation and temperature gotten by the following PV board are more ideal than the other. The normal control increment created by utilizing the following framework for a specific day (one – day test), is over 47% compared with the settled one.

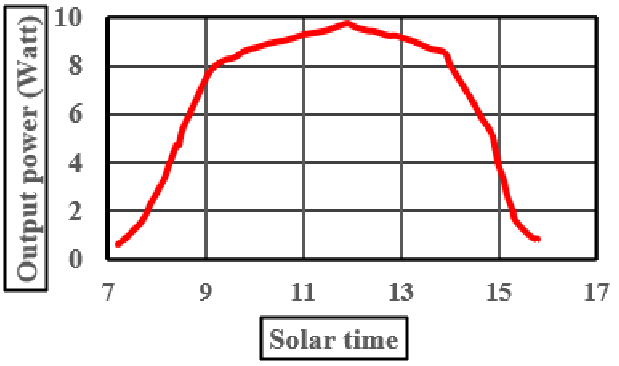

Figure 15: The Yield control of tracking PV boards for one- day

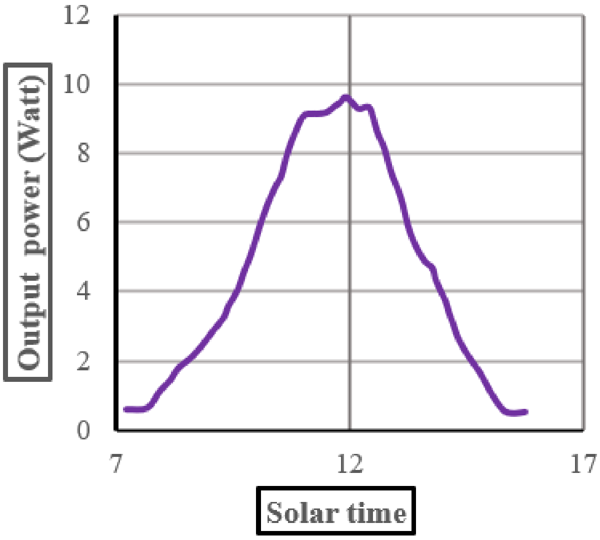

Figure 16: The Yield control of fix PV boards for one- day

Moreover, for these techniques the choice of sampling period is very critical; if the period is too short, energy production will be very low because of the increased number of electronic switching. If the period is too long, on the other hand, the MPP cannot be closely followed when rapid irradiance variation occurs. The purposes of the next tests are to investigate the dynamic characteristics of a PV system and to calculate the amount of power, voltage and current using the described MPPT controller. It should be noted that the generated power of has the same shape as the solar insulation input, the only difference is a small transient from the rapid insulation variation by using P&O and IC techniques. Comparing the output array voltage, it can be observed that the CV method is more stable with solar insulation variation. In particular due to lack of space, Figure 17 show the selected responses of the PV array using the IC, P&O and CV algorithms. In the first test, the MPPT controller is tested under a sunny day, and then cloudy and partially cloudy days to calculate the amount of the oscillation in PV operating points. The dynamic response of the PV array indicated that the CV technique delivers the more stable voltage, current and power waveforms with negligible oscillation amplitudes.

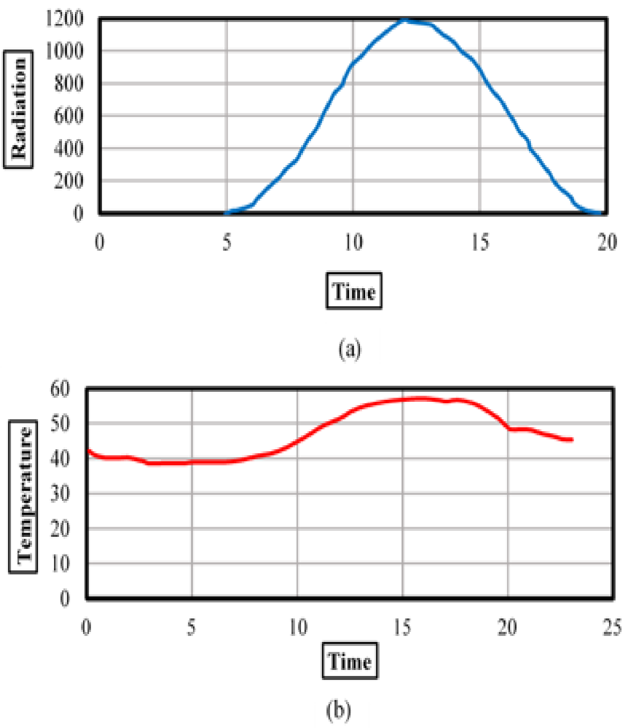

Figure 17: Radiation & Temperature (26th June)

V. CONCLUSION

A microcontroller base control system has been used and power gain can be increased of PV panels. The PV panels have been generated maximum output power and it is trying to give maximum efficiency above 47%, which had been compared with fixed PV panel. To sum up, Microcontroller based control and sensor-based tracking systems are highlighting solar tracking system which is performing based on efficiency through renewable energy. The hardware of a low price computerized photo voltaic power trapping device has been designed and effectively implemented. The designed that device which ensures 25 to 30% of more electrical electricity conversion than the contemporary static picture voltaic module system. Several tracker applied sciences at present are available on the market. Four LDRs are applied on the solar panel system to calculate the strength of solar radiation. The proposed solar monitoring device will automatically map the sunlight with the highest power point. Thus it is possible to improve the efficiency and strength of solar power output.

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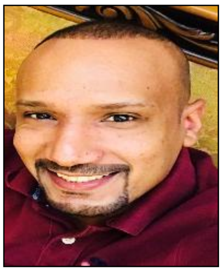
AUTHOR PROFILE



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