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# OBOUR INSTITUTE SOLAR PANEL MICROCONTROLLER BASED SINGLE AXIS SUN TRACKING SYSTEM

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## ABSTRACT

Electricity plays a key role now in our daily lives but the energy sources of electric power has been used in abundance and so researchers were compelled to find an alternate source of power leading to the discovery of solar energy. Solar energy is rapidly employed as an important means of expanding renewable energy resources. Solar energy is inexhaustible and eco-friendly and can be converted into electricity using photovoltaic panels especially in the high solar illumination areas. These panels can be used in a fixed form or used in a solar tracking system employing single axis as well as dual axis. In the fixed configuration, efficiency is lower since the panels will be tilted in a particular angle whereas in the tracking system solar panels are made to move either in single axis or dual axis. In a single axis system the panel is moved in an east to west direction with respect to the sun and it has better efficiency than panels in fixed form [1]. This work present sun tracking system with single axi control. Obour Institute solar system is used for the experiment verification of this research. The recorded Efficiency improvement reaches around 20% higher than fixed system.

## KEY WORDS

*Solar array, Sun tracker, Fixed mount solar system, Single-axis sun tracker, Solar energy, Microcontroller, MPP; Maximum Power Point*

## 1. Introduction

Sun tracking is one of the methods used to improve the efficiency of solar panel by producing more power with the same configuration through increasing the effective sun beams fallen on the solar panels by tracking the sun to make it nearly perpendicular to the solar panels that will lead to generate more power using the same solar panel size. Two types of sun tracking can be implemented; single axis and double axis sun tracking

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[2]-[5]. The proposed method in this research is the single axis method based on microcontroller to control the tracking action done by DC motor through H-Bridge. The advantages of this method are Simplicity, cheap and flexible to be reprogrammed through microcontroller software development.

## 2. SYSTEM CONFIGURATION

The solar panel under study is used for feeding lighting and fan loads working at Energy Conversion lab. The proposed configuration consists of the existing solar system of 130 Watt and the proposed circuit to carry out the sun tracking. It consists of DC motor, H-bridge, Microcontroller, two power supplies 12 and 5 V. that used to energize the DC motor and the microcontroller. The power supply 12 voltage is used to energies the DC motor through L298 H-Bridge. The control of H-Bridge is carried out by PIC16F877A microcontroller which is programmed using micro C V.5.6.1 language and supplied by the 5 volts power supply. Fig. 1 shows the block diagram representing the system configuration. The system control is based on fixed step motor angle generated by the microcontroller and triggered by the photocell at sunrise and reset again at sunset.

## 3. Simulation

Simulation is used to save effort time and money, protect hardware of project , illustrate the stages of output and make sure the goal of project have been achieved.simulation for two circuit is built ,the first one is stepper motor model and the second is DC motor by using proteus 7.8sp2.

Two circuits are simulated including the Microcontroller, DC motor, H-Bridge and the power supplies. The simulated circuit diagram is indicated in Fig 2 for stepper motor and Fig. 3 for DC motor models.The microcontroller software is constructed based on flow chart that describe the program sequential steps as shown in Fig. 4.Figure 5 represents the simulated motor angle plot versus time for 3 continuous cycles produced by the microcontroller.

## 4. Experiment results

Experiment results are recorded for both Fixed and sun Tracking systems. Two different measurement are recorded in two different days to validate the results at different temperatures. The first measurement taken each day is for I-V-P curves at different load levels by changing the resistance R at noon at 12:00 PM. The second measurement is the power versus time for both fixed and tracking systems from 8:00 AM to 5:00 PM recording current-voltage measurement and power-voltage curves.

### 4.1- First day results

The first day measurement was taken on 12th June. The ambient temperature recorded 35 $^{0}$ C.

#### 4.1.1- Current, Voltage and Power measurement

Table 1 lists the values of resistive loads, currents, voltages and power at 12:00 PM. Fixed system Current, power and voltage values are sketched for different values of resistive loads. Fig. 6 and Fig. 7 represent current-voltage and power voltage relations respectively showing the maximum power point; MPP with 18.7 Watt and maximum power point voltage of; VMPP = 10 volts.

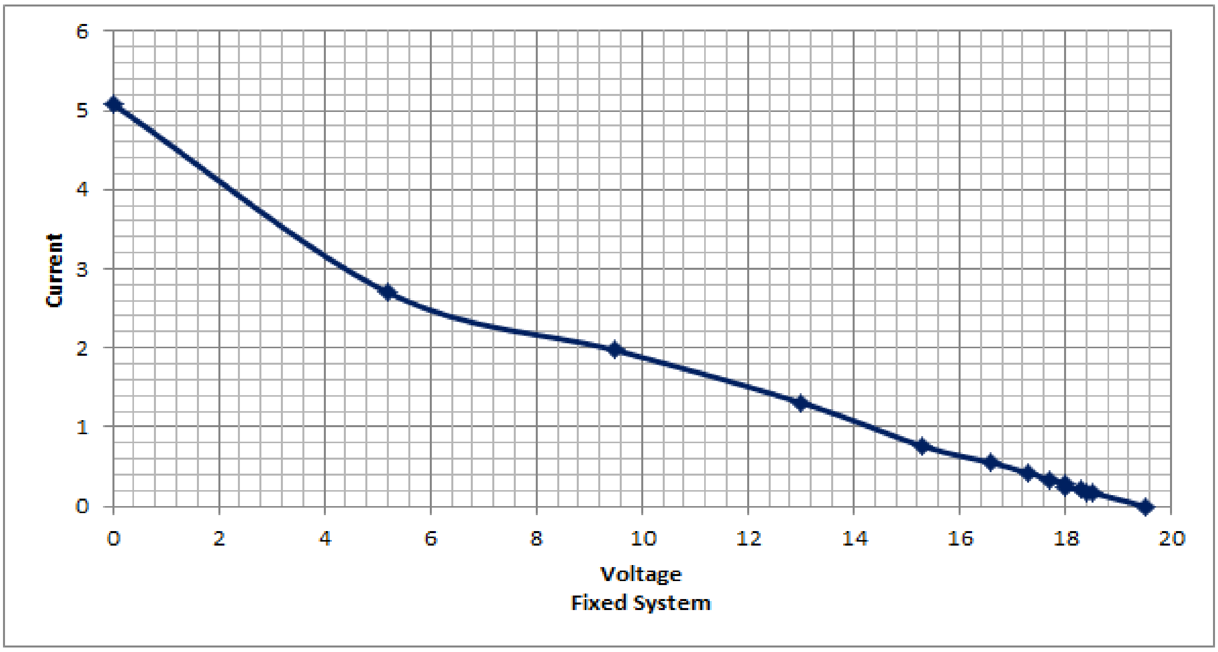


Fig: 6 I-V curve for fixed system measured on 12/6/2016

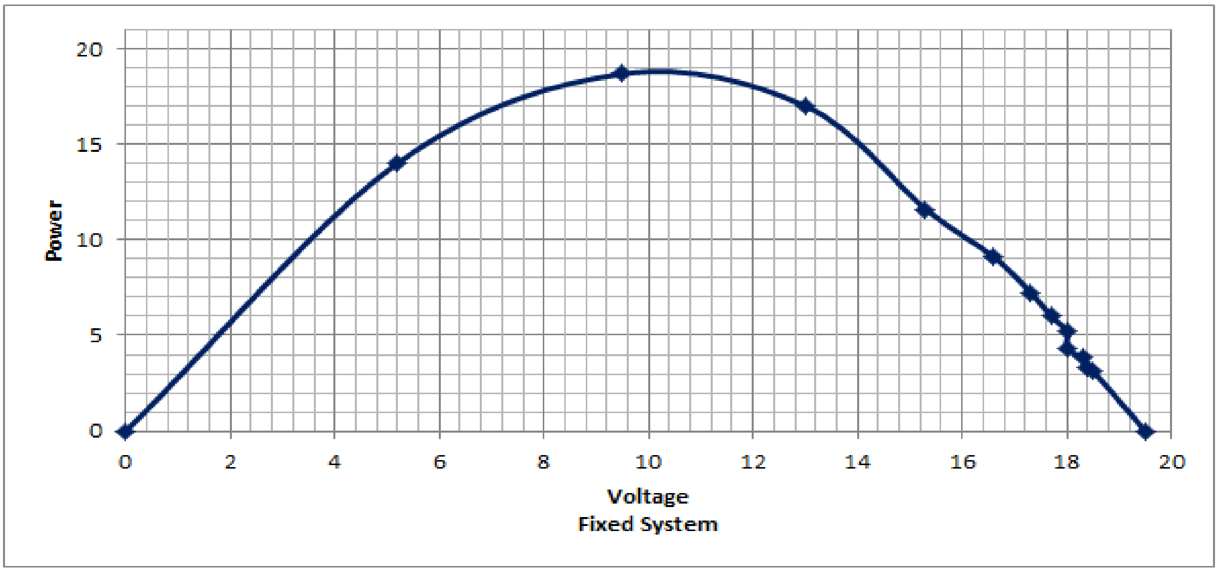


Fig 7 P-V curve for fixed system measured on 12/6/2016

The same measurements are taken for the tracking system. Fig. 8 and Fig. 9 indicate the I-V curve and P-V curves with maximum power of 20 Watt and VMMP of 10 volts.

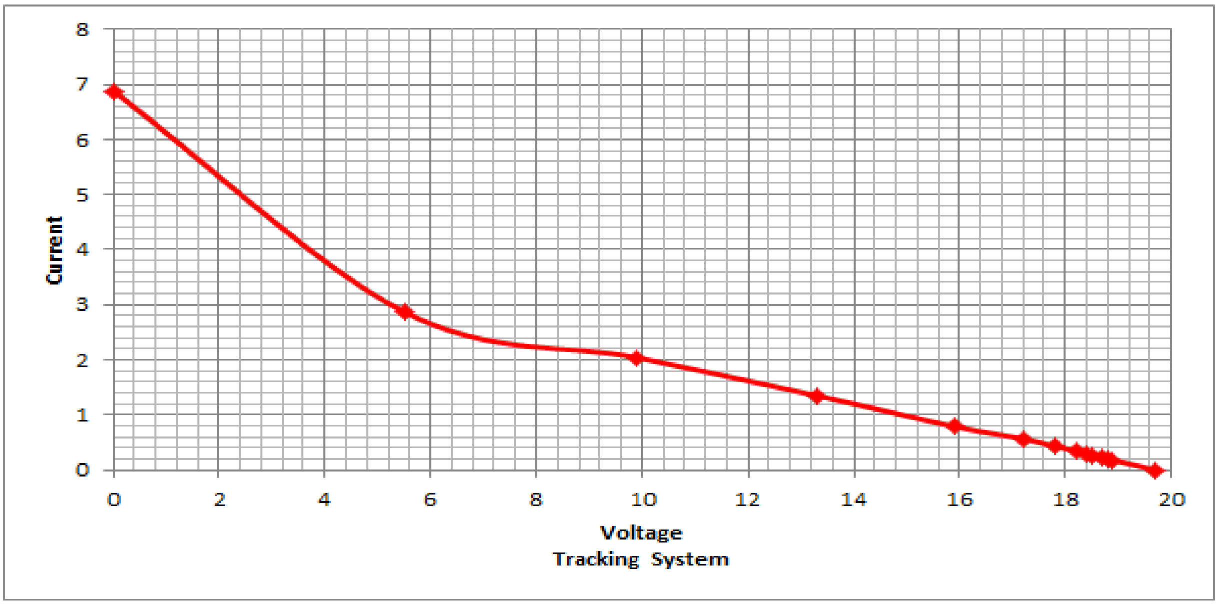


Fig: 8 I-V curve for tracking system measured on 12/6/2016

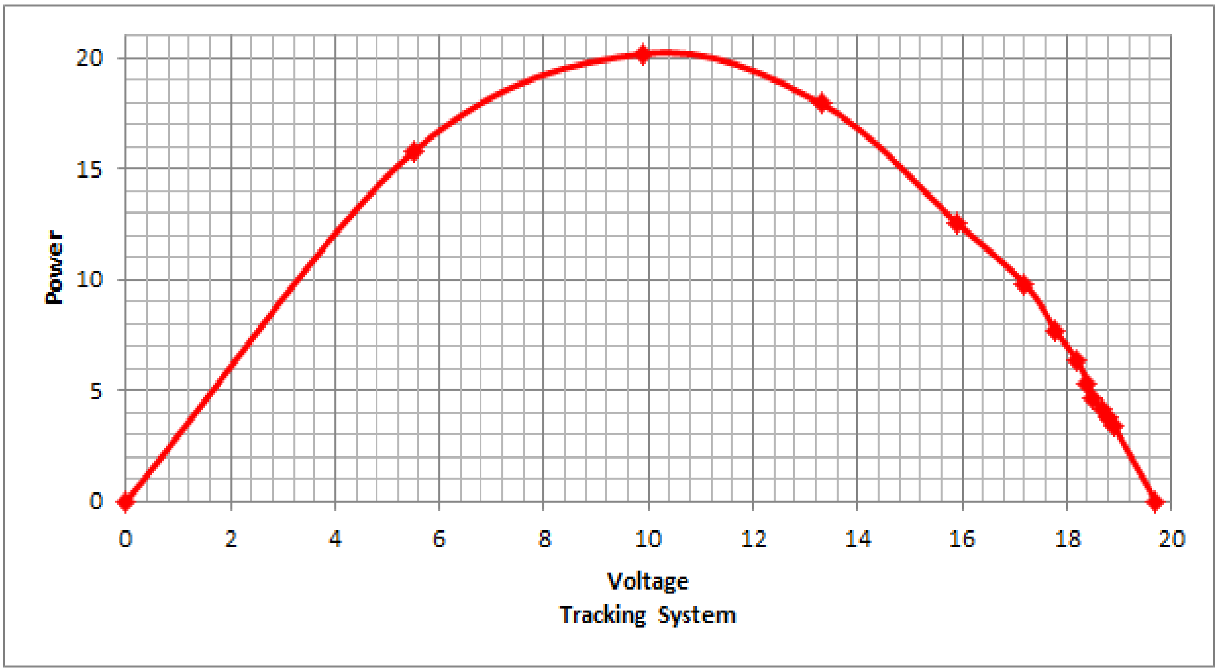


Fig 9 V-P curve for tracking system measured on 12/6/2016

Fig.10 shows comparison for the tracking system power versus fixed system power demonstrating that area under curve in tracking system is higher than fixed system which means higher power production by the same panels.

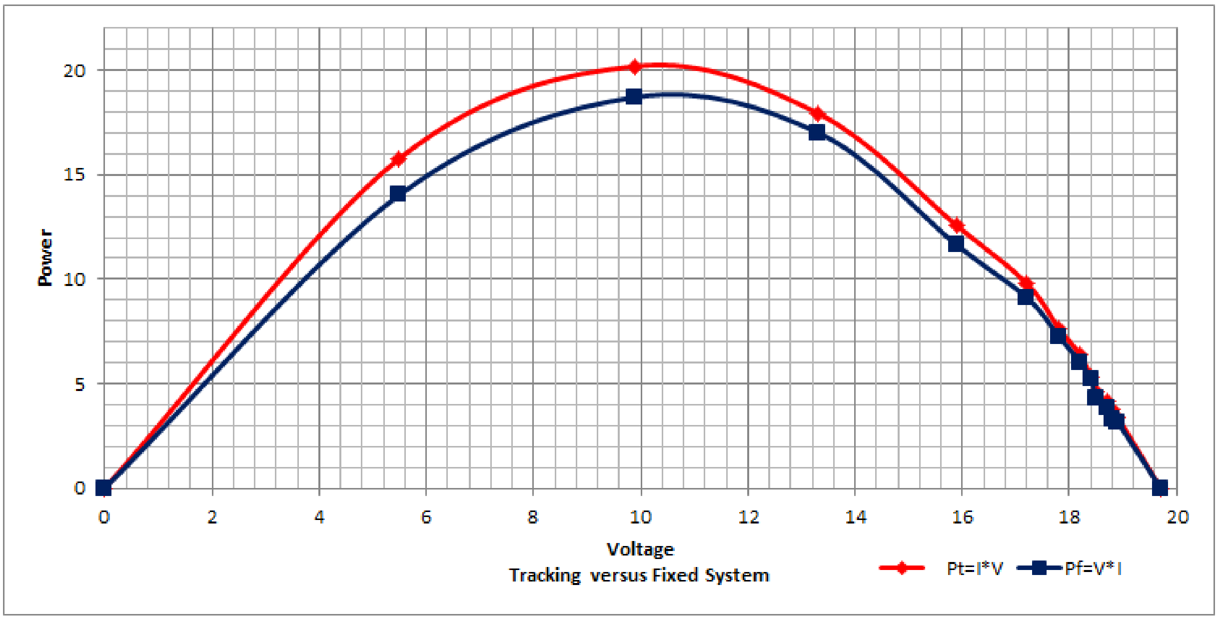


Fig 10 P-V curve for Tracking versus fixed system measured on 12/6/2016

### 4.1.2- Power versus time on 12-6-2016

This measurements are taken from 8:00 AM to 5:00 PM. Table 2 lists the power measured versus time for both systems.

Figure 11 and Fig. 12 indicate the individual curves with time for fixed and tracking respectively and Fig. 13 represents a comparison between fixed versus tracking with respect to time.

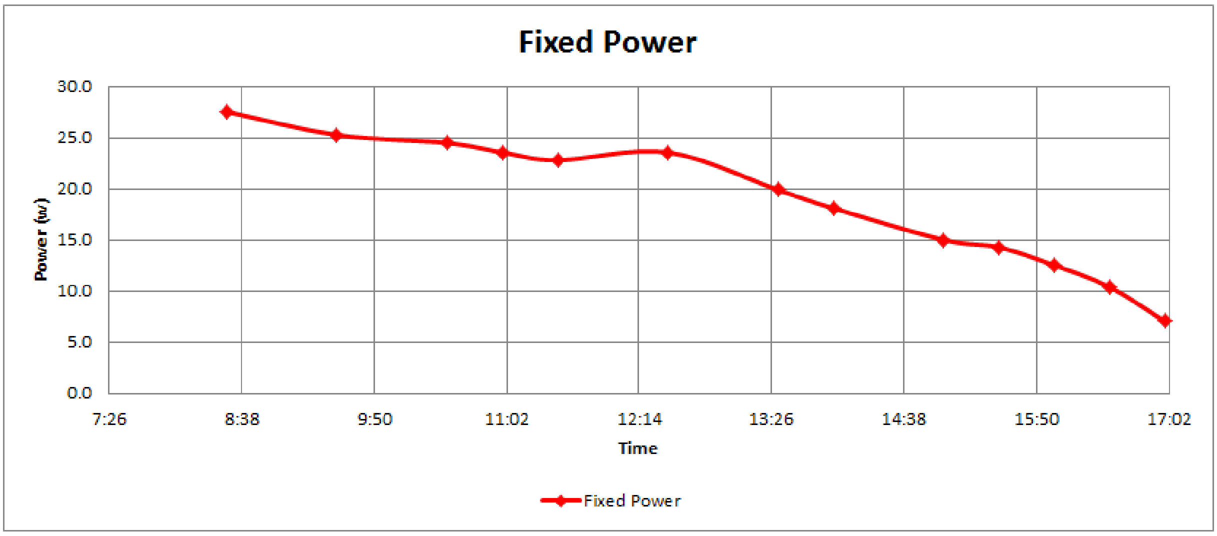


Fig 11 Power-time curve for fixed system measured on 12/6/2016

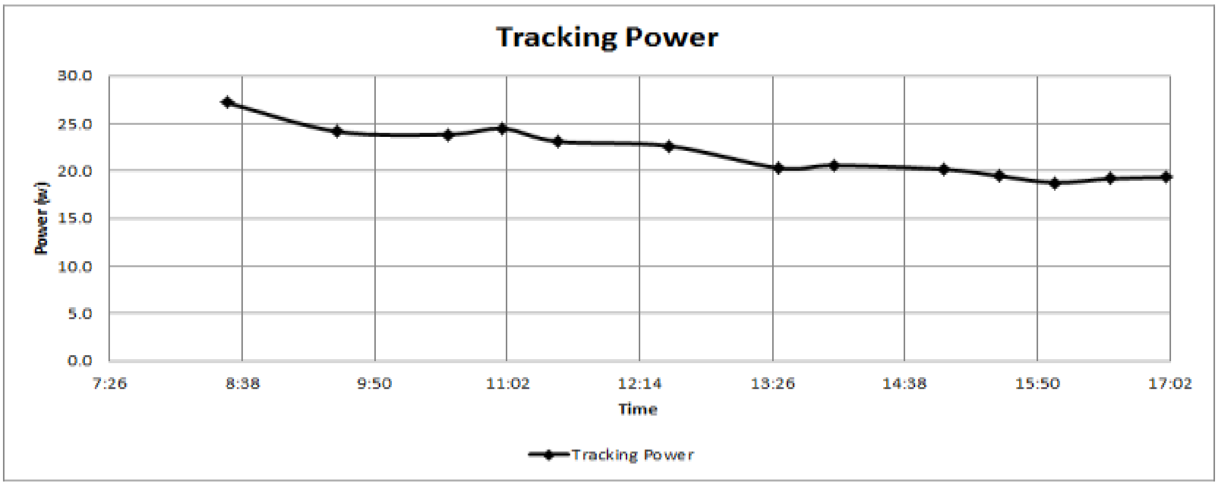


Fig 12 Power-time curve for tracking system measured on 12/6/2016

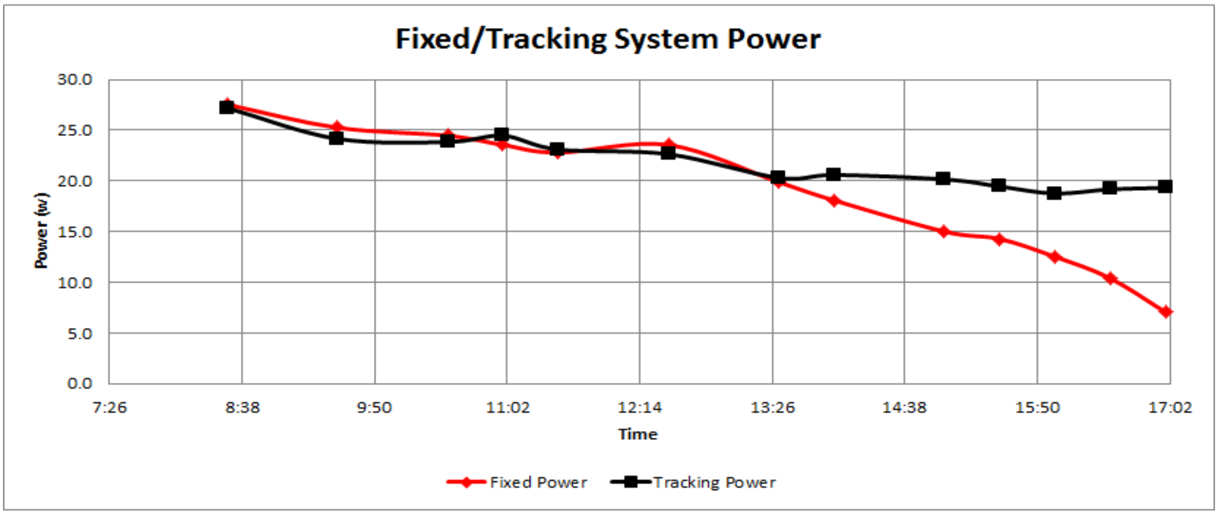


Fig 13 Power-time curve for fixed versus system measured on 12/6/2016

**4.2- Second day results:**

The second day measurement was taken on 14th June. The ambient temperature was 40 $^{0}$ C.

**4.2.1-Current, Voltage and Power measurement**

Table 3 lists the values of resistive loads, currents, voltages and power at 12:00 PM. Fixed system Current, power and voltage values are sketched for different values of resistive loads. Fig. 14 and Fig. 15 represent current-voltage and power-voltage relations respectively showing the maximum power point; MPP with 17.2 Watt and VMPP = 13 volts.

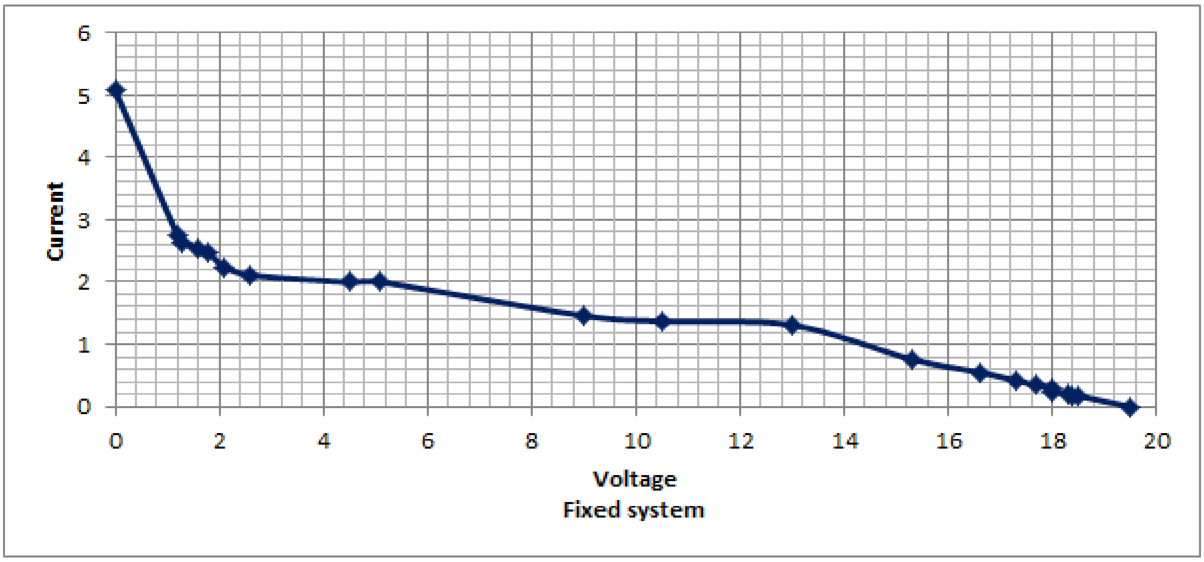


Fig 14 I-V curve for fixed system measured on 14/6/2016

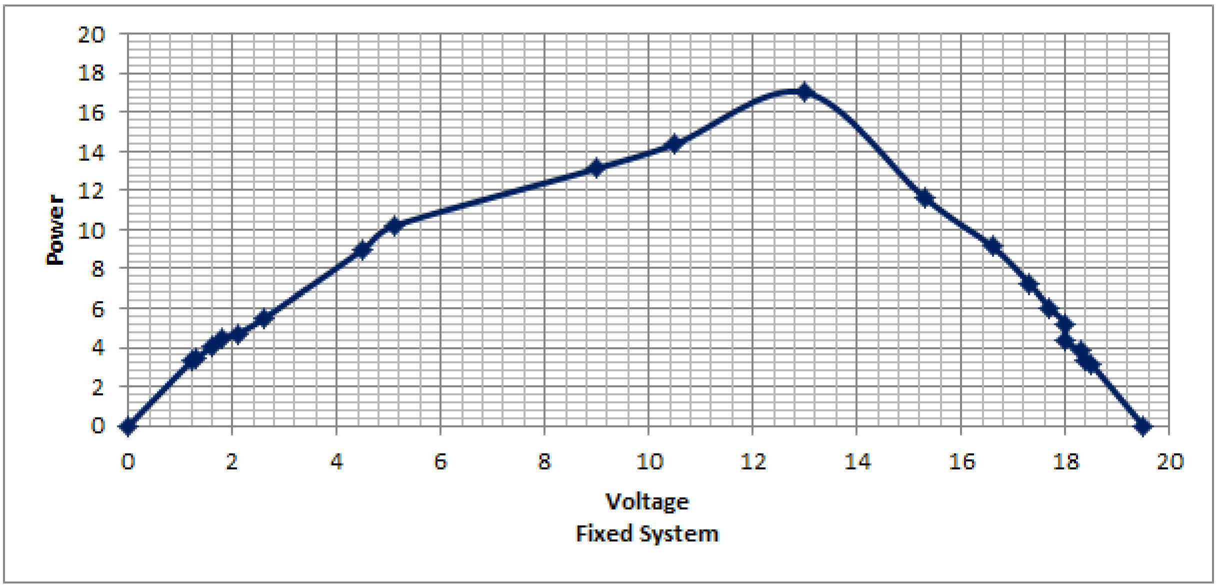


Fig 15 P-V curve for fixed system measured on 14/6/2016

The same measurements are taken for the tracking system. Fig. 16 and Fig. 17 indicate the I-V curve and P-V curves with maximum power of 18 Watt and VMMP of 13 volts.

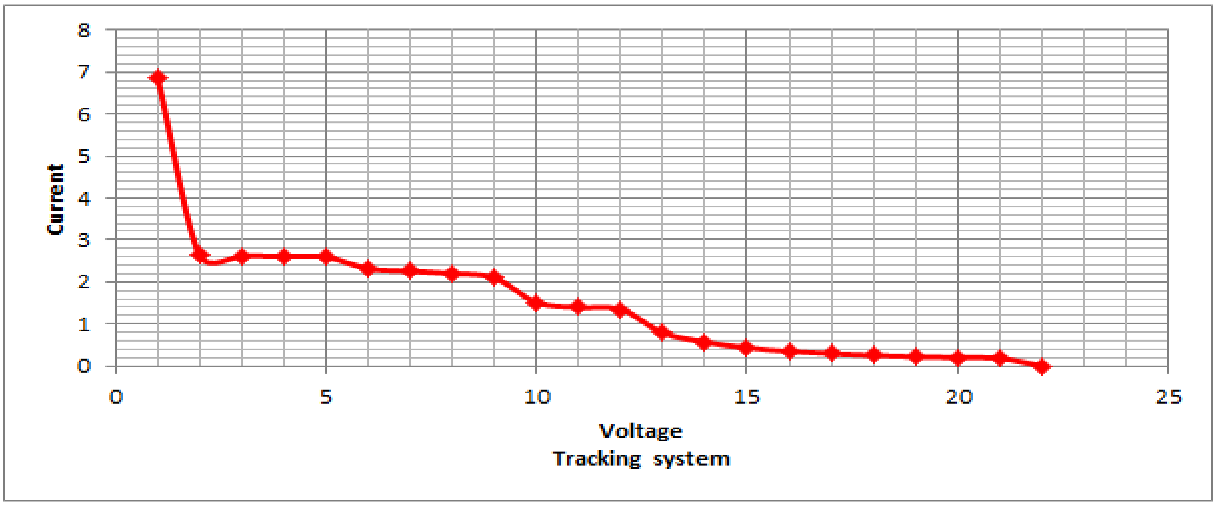


Fig 16 I-V curve for tracking system measured on 14/6/2016

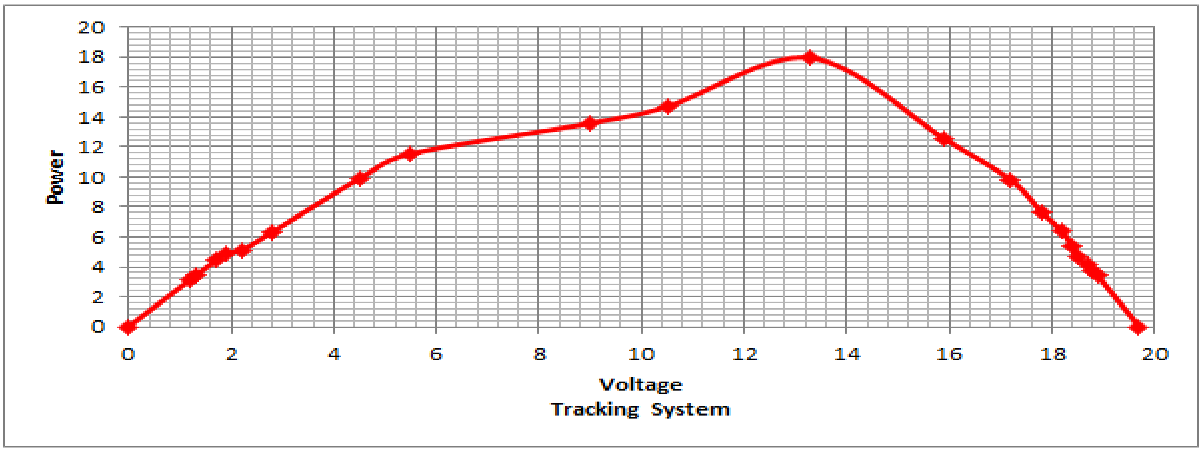


Fig 17 P-V curve for tracking system measured on 14/6/2016

Fig.18 shows the tracking system power versus fixed system power demonstrating that area under curve in tracking system is higher than fixed system which means higher power produced by the tracking system with the same solar panels.

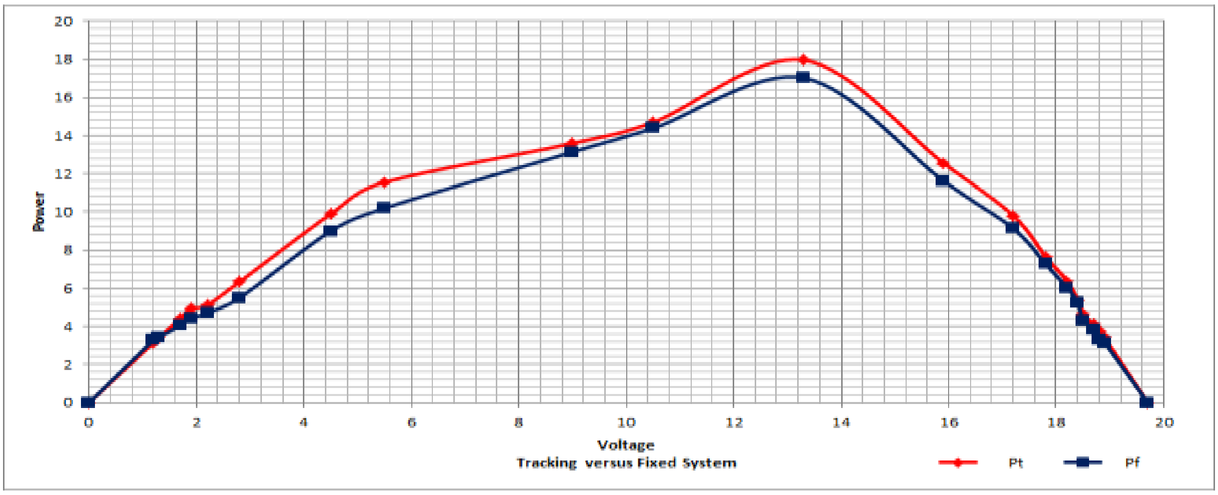


Fig 18 P-V curve for Tracking versus fixed system measured on 14/6/2016

**4.2.2- Power versus time on 14-6-2016:**

This measurements are taken from 8:00 AM to 5:00 PM for both systems. Table 4 lists the power measured versus time for both systems.

Figure 19 and Fig. 20 indicate the individual power curves versus time for fixed and tracking system respectively and Fig. 21 represents a comparison for fixed versus tracking system power with respect to time.

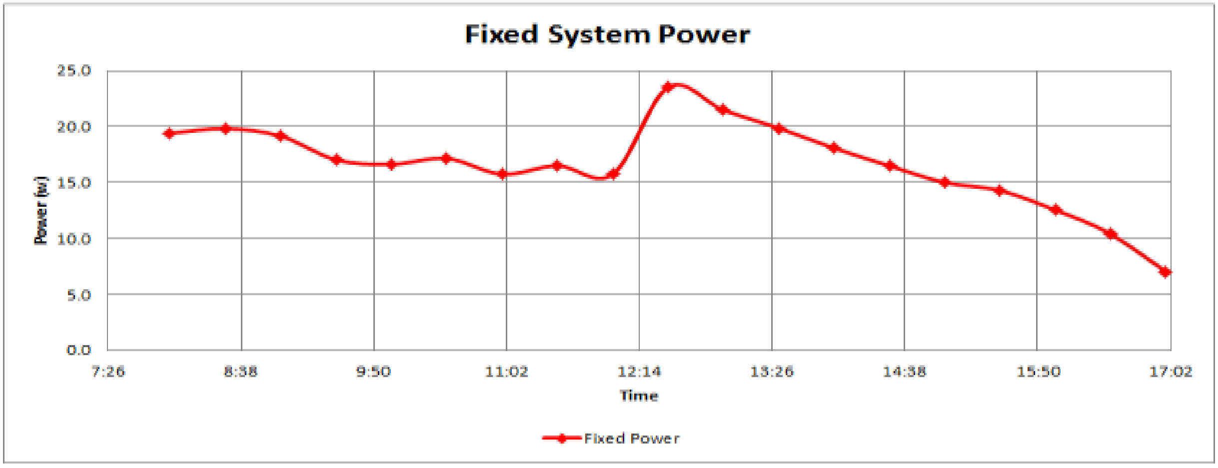


Fig 19 Power-Time curve for fixed system measured on 14/6/2016

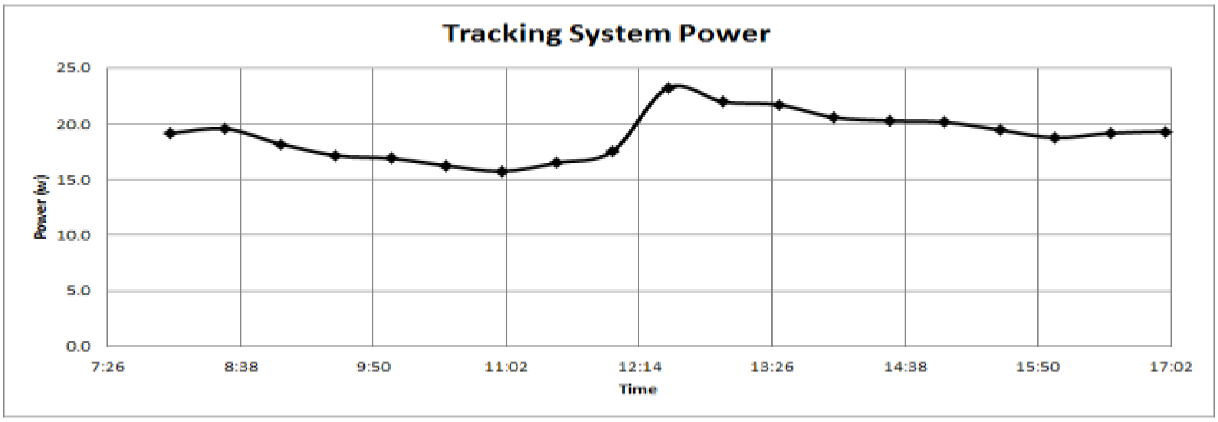


Fig 20 Power-Time curve for tracking system measured on 14/6/2016

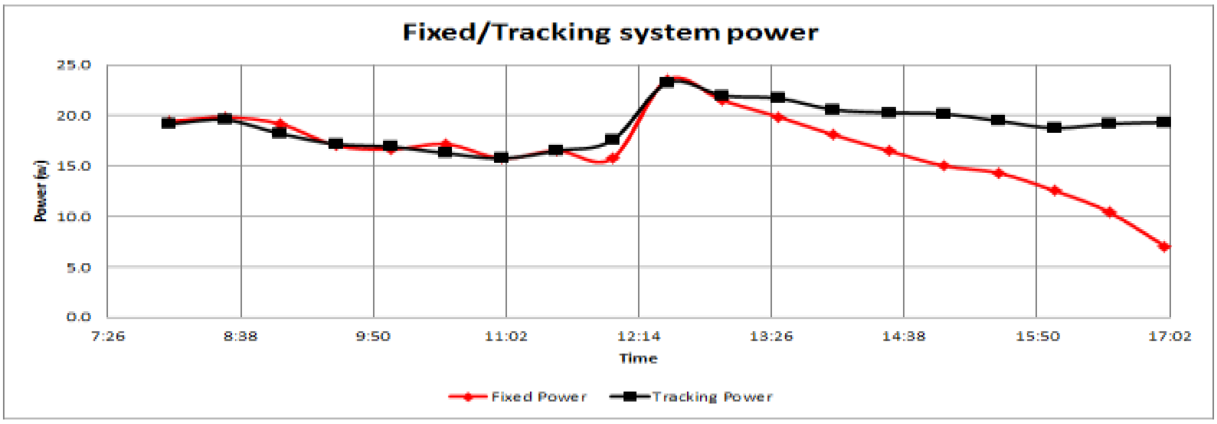


Fig 21 Power-Time curve for fixed and Tracking system measured on 14/6/2016

From the previous measurement, this work verify the overall system efficiency increasing due to utilization of single axis sun tracking system with simple, cheap and programmable control circuit by employing microcontroller.
The recorded power on 12 June with ambient temperature 35 $^{0}$ C is higher than power on 14th June with temperature of 40 $^{0}$ C because the solar panel efficiency is increased with lower temperature at the same solar irradiation (assuming we have the same solar irradiation during both days).
Fig. 22 indicates the system real photo configuration including the solar panels, DC motor and control circuit. Figure 23 shows the positions of the solar panel following the sun starting from the initial position at sunrise to noon position and ended by final position at sunset.

## 5. Conclusion

The efficiency of the single axis tracking system over the fixed panel is recorded as 19% improvement. Proving that the efficiency and maximum power in tracking signal in better than fixed system. The efficiency is improved and the maximum power point is increased in single axis tracking system. Improve solar panel efficiency by employing sun tracking system to optimize the solar radiation received by the solar panel during the day to maximize the output of the solar panel. Another advantage is the flexibility of the system to reprogram the microcontroller to control the dc motor for better tracking and the possibility to add more features as the double axis tracking system and mirror to dense the sunlight and concentrate it for more and more efficiency.
The disadvantage is the added cost to the budget needed for the system build up and maintenance needed periodically for the outdoor moving parts installation.

## 6. Future work

The efficiency of the single-axis tracking system can be increased even more by placing a mirror or concave lens on top of the panel. The use of lens or mirror increases the tracker's efficiency since large amount of sunlight is concentrated on the panel and large power is generated. It can also reduce the size of the solar cell required to generate large power. It also has high optical efficiency.
The efficiency of the single-axis tracking system can be increased by placing a dual-axis on the panel. The use of dual-axis increases the tracker's efficiency since large amount of sunlight is concentrated on the panel and large power is generated.

## 7. Acknowledgement

The author would like to express his most sincere gratitude to those people, listed in the References, who in the past years have greatly contributed to the advancement of the technique applied in this paper. Also the energy conversion laboratory in electronic and communication department of Obour Institute gives this research many kinds of support.

**References**

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## Figures and Tables

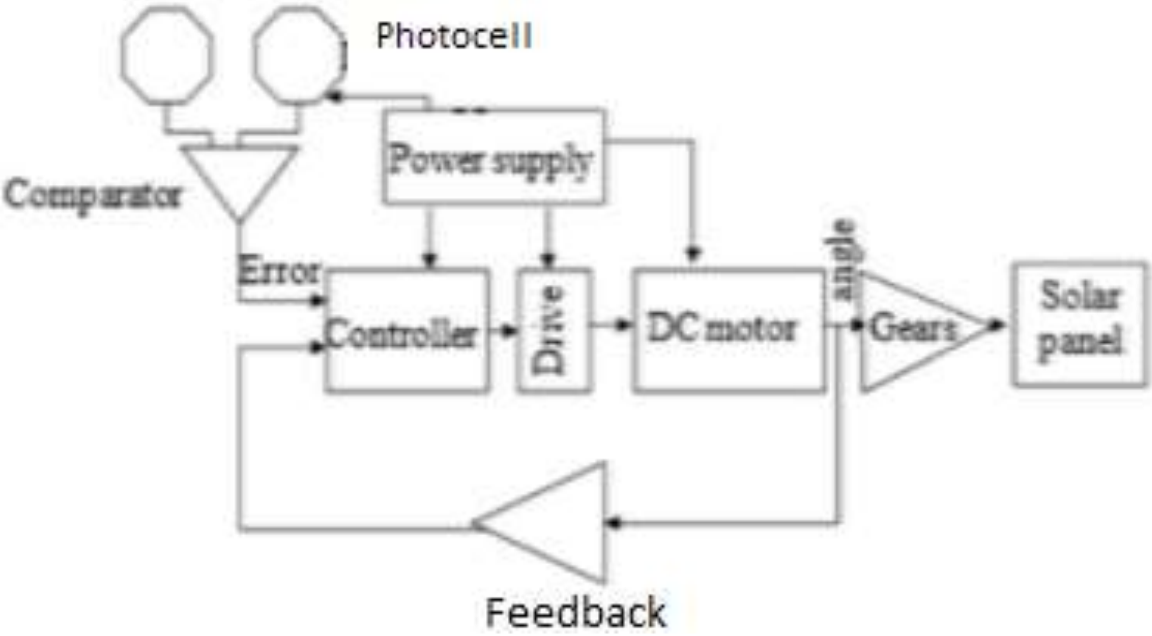
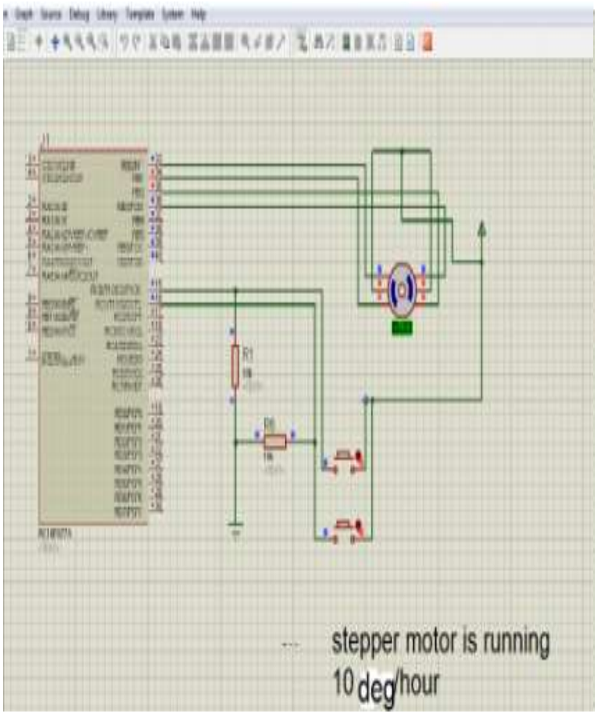



Fig. 1 Control circuit block diagram



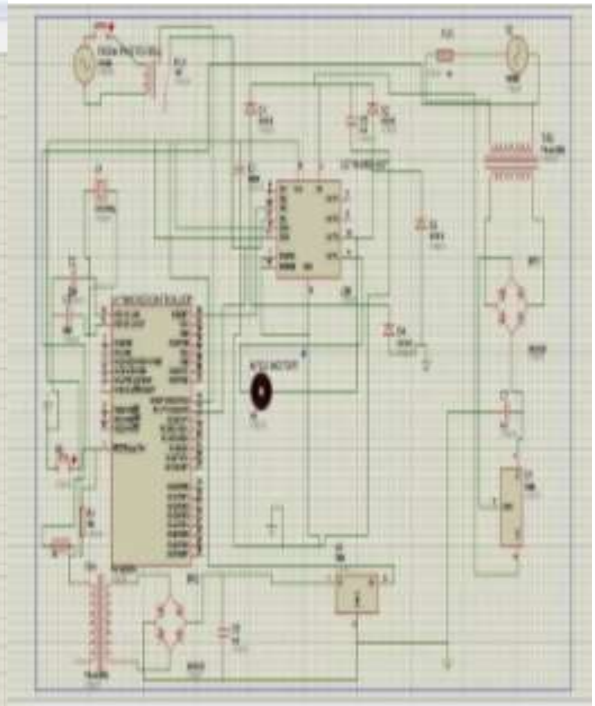



Fig. 2 Simulated stepper motor model.

Fig. 3 Simulated DC motor model

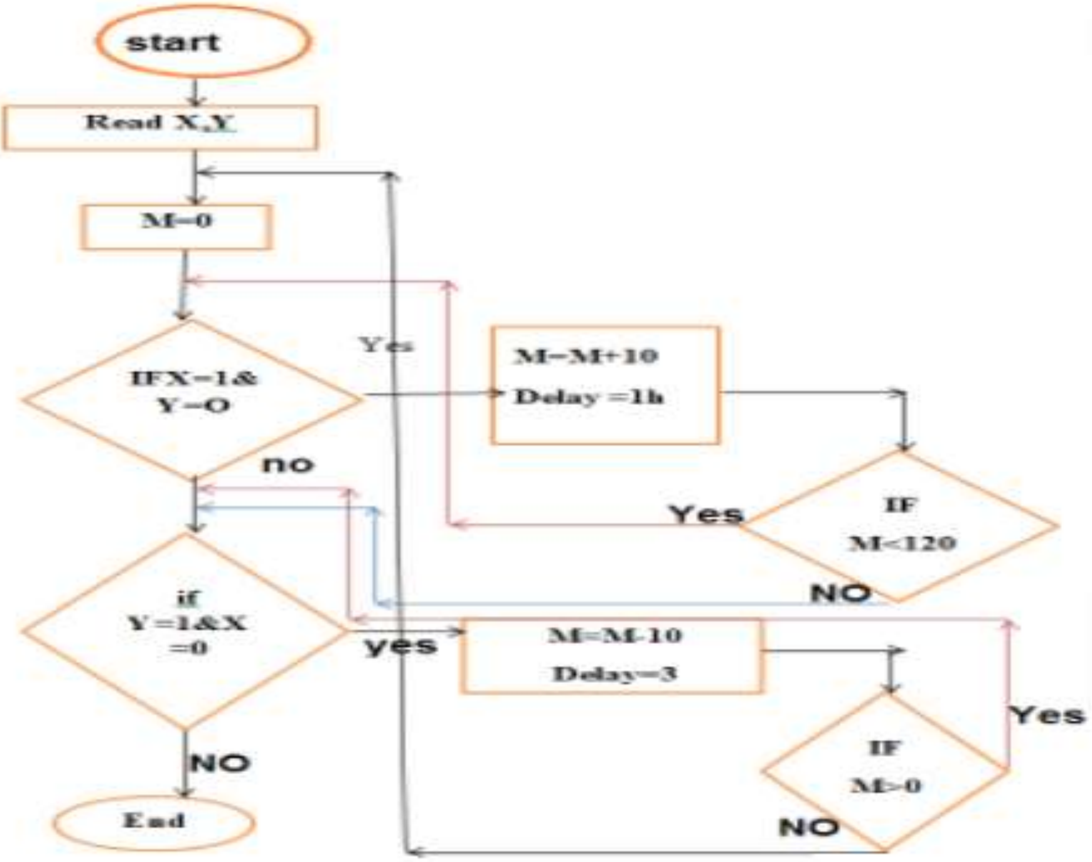



Fig. 4 Stepper Motor model flow chart


Fig.5 Simulated Solar panel angle controlled by microcontroller

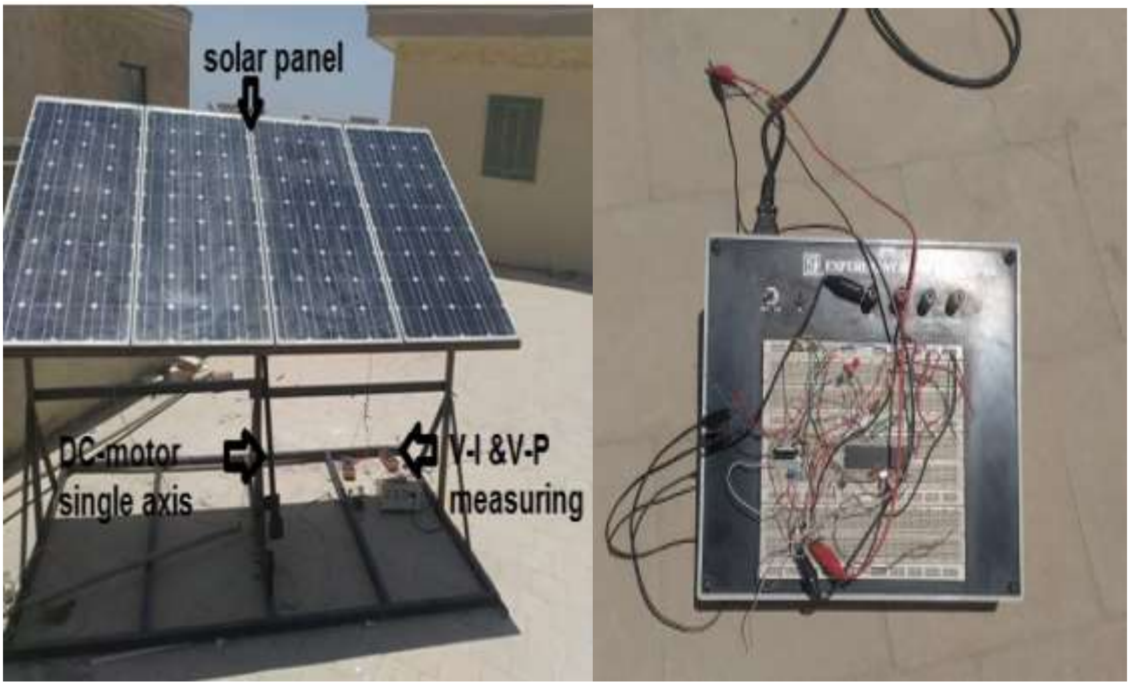



Fig. 22 Solar System and control circuit real photo


Fig. 23 System Tracking positions, initial, middle and final

**Table 1 R-V-I-P measurement on 12th June**

| 12 JUNE | | | |
|---|---|---|---|
| FOR FIXED PANEL | | | |
| R | V | I | Pf=V*I |
| SC | 0 | 5.08 | 0 |
| 2 | 5.2 | 2.7 | 14.04 |
| 5 | 9.5 | 1.97 | 18.715 |
| 10 | 13 | 1.31 | 17.03 |
| 20 | 15.3 | 0.76 | 11.628 |
| 30 | 16.6 | 0.55 | 9.13 |
| 40 | 17.3 | 0.42 | 7.266 |
| 50 | 17.7 | 0.34 | 6.018 |
| 60 | 18 | 0.29 | 5.22 |
| 70 | 18 | 0.24 | 4.32 |
| 80 | 18.3 | 0.21 | 3.843 |
| 90 | 18.4 | 0.18 | 3.312 |
| 100 | 18.5 | 0.17 | 3.145 |
| OC | 19.5 | 0 | 0 |

**Table 2 Power -Time reading for fixed and tracking system on 12th June**

| 12- June Readings | | |
|---|---|---|
| Time | Fixed Power | Tracking Power |
| 8:30 | 27.5 | 27.2 |
| 9:30 | 25.3 | 24.2 |
| 10:30 | 24.5 | 23.9 |
| 11:00 | 23.6 | 24.5 |
| 11:30 | 22.8 | 23.1 |
| 12:30 | 23.6 | 22.6 |
| 13:30 | 19.9 | 20.3 |
| 14:00 | 18.1 | 20.6 |
| 15:00 | 15.0 | 20.2 |
| 15:30 | 14.3 | 19.5 |
| 16:00 | 12.5 | 18.8 |
| 16:30 | 10.4 | 19.2 |
| 17:00 | 7.1 | 19.3 |
| Total | 244.4 | 283.2 |
| Average | 18.8 | 21.8 |
| Increase | 16.60% | |

**Table 3 R-V-I-P Measurements on 14-June**

| 14 JUNE | | | |
|---|---|---|---|
| Fixed at 12:00 PM | | | |
| R | V | I | Pf=V*I |
| SC | 0 | 5.88 | 0 |
| 0.47 | 1.2 | 2.74 | 3.288 |
| 0.52 | 1.3 | 2.64 | 3.432 |
| 0.58 | 1.6 | 2.54 | 4.064 |
| 0.78 | 1.8 | 2.46 | 4.428 |
| 1 | 2.1 | 2.24 | 4.704 |
| 1.179 | 2.6 | 2.11 | 5.486 |
| 1.74 | 4.5 | 2 | 9 |
| 2 | 5.1 | 2 | 10.2 |
| 2.97 | 9 | 1.46 | 13.14 |
| 5 | 10.5 | 1.37 | 14.385 |
| 10 | 13 | 1.31 | 17.03 |
| 20 | 15.3 | 0.76 | 11.628 |
| 30 | 16.6 | 0.55 | 9.13 |
| 40 | 17.3 | 0.42 | 7.266 |
| 50 | 17.7 | 0.34 | 6.018 |
| 60 | 18 | 0.29 | 5.22 |
| 70 | 18 | 0.24 | 4.32 |
| 80 | 18.3 | 0.21 | 3.843 |
| 90 | 18.4 | 0.18 | 3.312 |
| 100 | 18.5 | 0.17 | 3.145 |

| | | | |
|---|---|---|---|
| OC | 19.5 | 0 | 0 |

**Table 4 Power-Time reading for fixed and tracking system on 14th June**

| Time | Fixed Power | Tracking Power |
|---|---|---|
| 8:00 | 19.4 | 19.2 |
| 8:30 | 19.8 | 19.6 |
| 9:00 | 19.2 | 18.2 |
| 9:30 | 17.0 | 17.2 |
| 10:00 | 16.6 | 16.9 |
| 10:30 | 17.2 | 16.3 |
| 11:00 | 15.8 | 15.8 |
| 11:30 | 16.5 | 16.5 |
| 12:00 | 15.8 | 17.6 |
| 12:30 | 23.6 | 23.3 |
| 13:00 | 21.5 | 22.0 |
| 13:30 | 19.9 | 21.7 |
| 14:00 | 18.1 | 20.6 |
| 14:30 | 16.5 | 20.3 |

| | | |
|---|---|---|
| 15:00 | 15.0 | 20.2 |
| 15:30 | 14.3 | 19.5 |
| 16:00 | 12.5 | 18.8 |
| 16:30 | 10.4 | 19.2 |
| 17:00 | 7.1 | 19.3 |
| Total | 316.1 | 361.8 |
| Average | 16.6 | 19.0 |
| Increase | 19% | |