# OPTIMUM ORIENTATION OF PHOTOVOLTAIC (PV) MODULE FOR ELECTRIC POWER GENERATION IN OGBOMOSO AREA

***Sanusi, Y.K, Fajinmi G.R and Awodugba A.O***
***Department of Pure and Applied Physics***
***Ladoke Akintola University of Technology, Ogbomoso, Nigeria***
***E-mail: sanusiyekinni@yahoo.com***

## ABSTRACT

The solar energy may be used to produce electricity using photovoltaic (PV) modules by a photovoltaic conversion. Among several factors that influence the conversion efficiency of a photovoltaic solar system is to use optimum orientation (tilt angle) of a photovoltaic module. In this work, the measurements of the optimum tilt angles are daily studied during one complete year 2007. Data treatment and analysis are carried out. The results are discussed and the optimum tilt angles of photovoltaic module for the electric power generation at LAUTECH, Ogbomoso area are determined. The maximum output power at an angle 8 degree and 12 degree for dry season (February to April) and rainy season (June to September) respectively were obtained. The results can then be used as a baseline data for the optimal utilization of a P.V module system for the electric power generation in the area of study and other areas having similar radiation characteristics.
**Keywords**: solar energy, power output, tilt angle, electricity.

## INTRODUCTION

In order to prevent global warming, an important measure is needed to reduce the greenhouse gas emissions. As a result of this, people are paying more attention to the use of natural energy, such as solar energy, a long-term, inexhaustible, and environmentally friendly and reliable energy source. One of the main forms of solar energy technology is solar PV power system, which has been developed rapidly in the past few years. Proper installation, especially the tilt angle of this PV system, directly affects the its output. Determination of the optimal tilt angle of a solar PV module depends on the solar radiation characteristics, season and reflectivity in the local area (Naihong S. et al, 2006). It has been found that for every location on earth with specific radiation characteristics, there is an optimal tilt angle (Baltas P, 1986) for the best solar energy utilization. Though, some theoretical research has been carried out regarding the optimal tilt angle using the weather data observed by meteorological agency (Barry, 1995, David et.al. 1997 ). However, little or no research, especially in the area of study, has been done on experimental and parameters studies covering the optimal tilt angle of the PV modules.

However, this paper evaluates the performance of amorphous silicon solar modules at different tilt angle in fixed orientation in order to determine the best tilt angle of the photovoltaic module for each month at Ogbomoso area by field testing measurements in the outdoor conditions for electric power generation.

## Experimental setup

The photovoltaic solar array of three flat solar modules connected in parallel configuration was raised fifty centimeter above the roof-top using iron steel pole at the back of P/A Physics department, Ladoke Akintola University of Technology, Ogbomoso. Each flat plate solar panel containing 72 crystalline silicon solar cells, rated 27W peak, 19V, model GIVO, ARCO. SOLAR IWC and manufactured by BP solar system LTD. To this photovoltaic solar array, a low resistance ammeter was connected in series while a high resistance voltmeter was connected in parallel to the 10 Ohms resistor using as a load (see figure 1a and 1b).

## Measurements

The measurements start when the photovoltaic solar array is completely horizontal mode (i.e. the tilt angle is $0^o$). At every four degree variation in the tilt angle, the maximum output current and voltage values of the solar system were monitored, measured and recorded. The measurements are carried out during the clear sky days (i.e. cloudless) between 1:00pm and 2:00pm through out the period of studies for one complete year, 2007. The maximum power output for the solar PV system in each day was determined from the measured maximum current and voltage values. Along the way solar intensity and surrounding temperature of the day were monitored, measured and recorded using five in one Auto ranging Digital Multimeter (serial number MS8209).
Using computer software for fitting the data smoothly for each day of measurements, the optimum tilt angles are determined. Where the optimum tilt angle is the angle at which the maximum average output power is obtained.

## RESULTS AND DISCUSSION

**Radiation intensity and tilt angle**: The monthly average total radiations intensity receives by PV modules of different selective tilt angles are shown in figure 2. The average tilt angle at which the PV module receives the largest radiation was $0^O$, in the month of January, February, March, April, November and December (dry season), and $8^O$ between the month of May to October (raining season).

## Optimal Tilt Angle

Figures 3 are the variation of the maximum power output of the photovoltaic solar system $P_o$ with the corresponding tilt angle for the period covered by the report. The figures were obtained by fitting a polynomial of the $3^{rd}$ degree to the data, the maximum power output and the corresponding tilt angle. The polynomials obtained for the variables are indicated in the respective graph of each month.

Table 1 presents the maximum value of the power output produced by the photovoltaic system in different months of the year and at the corresponding tilt angle. It is therefore plausible to say that at the approximately tilt angle of 8 or 12 degree (depending on the month of the year), maximum values of power output are expected.

Further from these figures 3, it can be suggested that the value of the tilt angle at the turning point could serve as an optimum operating tilt angle of the photovoltaic solar system performance ( i.e $8^O$ for the months of January, February, March, April, November and December and $12^O$ for the months of May, June, July, August, September and

October) . For below and above the values of the tilt angle at the turning point, the performance output of the system begins to drop.

## CONCLUSION

Among several factors that influence the performance of photovoltaic system design are the orientation and tilt angle of a photovoltaic panel. It is obvious from this work that the angle at which photovoltaic array is installed would affect the magnitude of energy produce by the photovoltaic solar system. More so the research work shows that there is a direct proportionality between the performance power output of photovoltaic solar system and the tilt angle of solar panel or array. We therefore conclude that the experimental results of the optimum tilt angles obtained from this work are reliable for the application in the field of design, construction and predicting the performance of a photovoltaic solar system for the electric power generation at the Ogbomoso area and any other areas that have similar radiation characteristics.

## REFERENCES

Baltas, P., M.Tortoreli, and P.E. Russell (1986): Evaluation of power output for fixed and step tracking photovoltaic arrays. *Solar Energy*, 37(2): 17-163.

Barry R.G and Chorley R.J (1995): Atmosphere weather and climate. Routledge London. Pp 15-18, 34.

Naihong S., Nobuhiro K, Yasumitsu K and Hirotora S. (2006): Experimental and Theoretical Study on the Optimal Tilt Angle of Photovoltaic Panels. Journal of Architecture and Building Engineering/ Nov./ 405.

Naihong S. (2004): Theoretical Calculation and Parameter Analysis on Optimum InclinedAngle of Solar Module, The 3rd International Workshop on Energy and Environment of Residential Building. China pp 264-270.

David L. K J, Kratochvil A. k and William E.B: (1997): Measuring Solar Spectral and William E. Boyson
Presented at the 26th IEEE photovoltaic Specialists Conference, 1997, Anaheim, California.

**Table 1: Optimum Tilt Angle in Different Month of the Year.**

| Month of the Year | Optimum Tilt Angle (degree) |
|---|---|
| January | 8.20 |
| February | 8.10 |
| March | 8.00 |
| April | 8.00 |
| May | 12.10 |
| June | 12.10 |
| July | 11.98 |
| August | 11.96 |
| September | 12.20 |
| October | 12.00 |
| November | 8.00 |
| December | 8.10 |

**Figure 1a: The Prototype of Solar Array of Test ASPS**

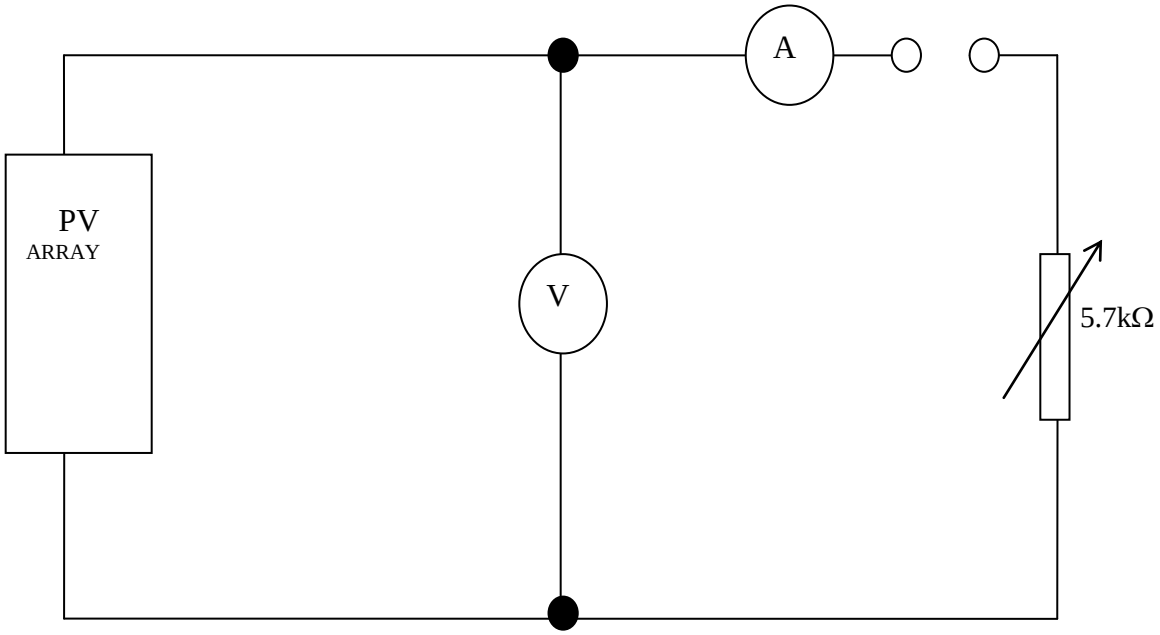
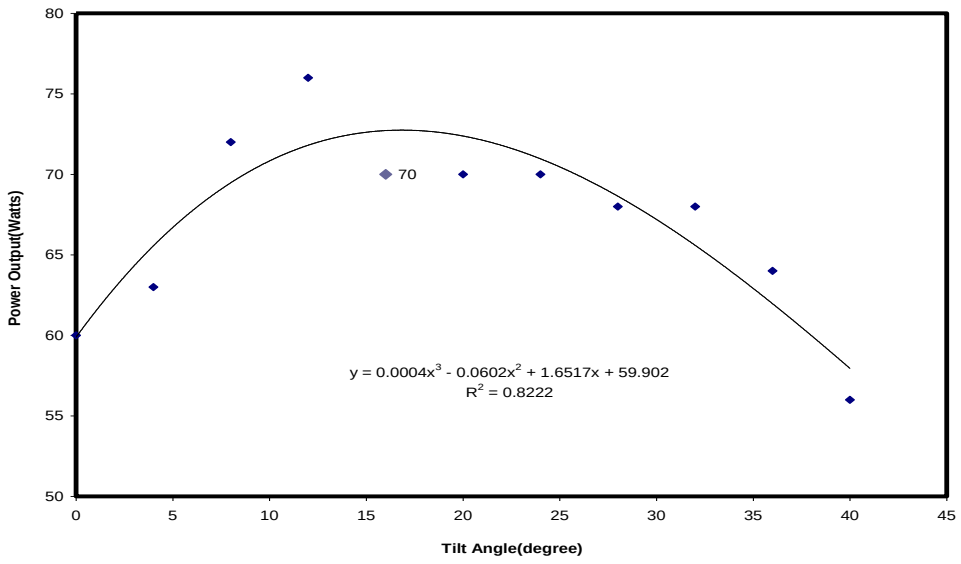
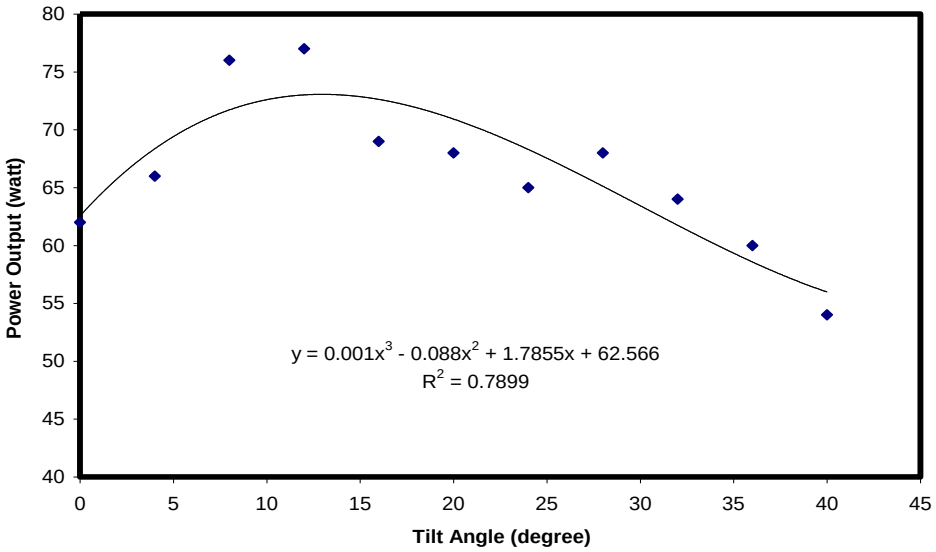


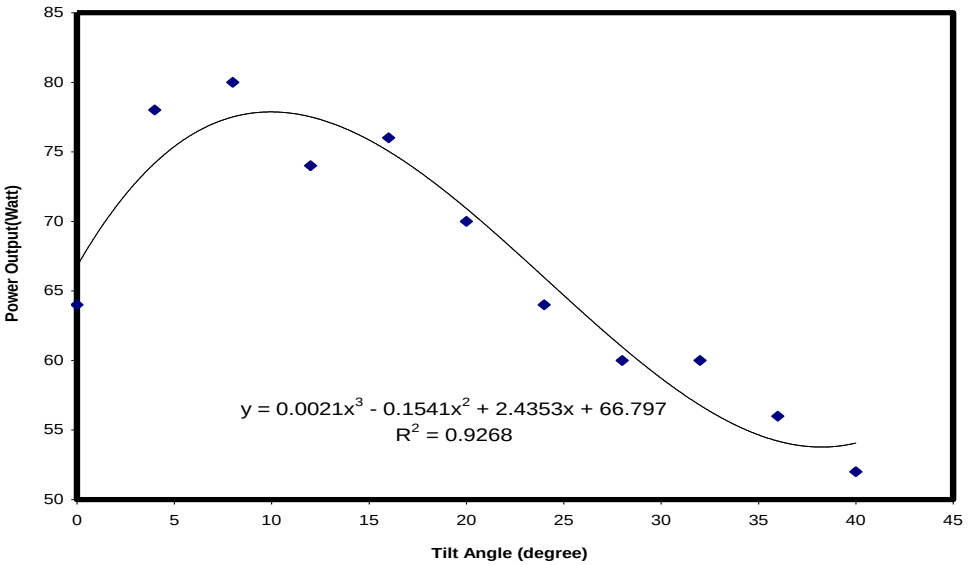

**Figure 1b: Circuit model of the Experimental set-up.**



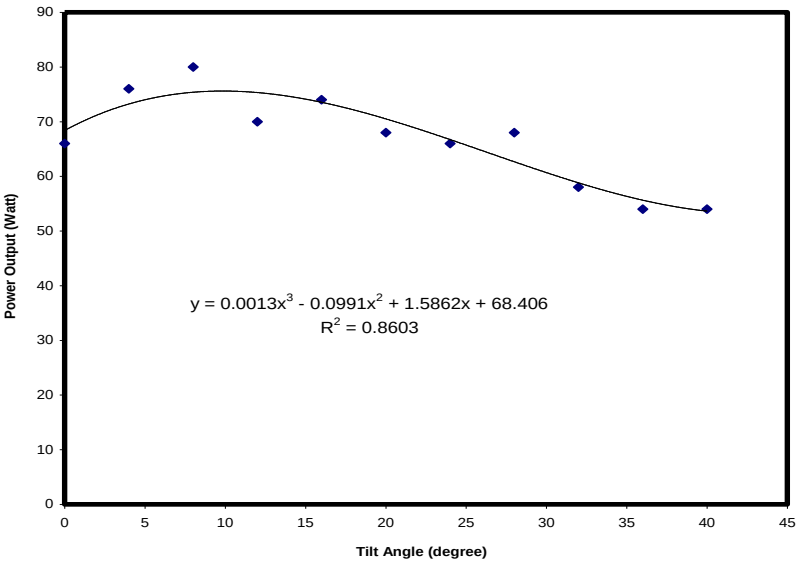

**Performance of PV Module at Different Tilt Angle for January**



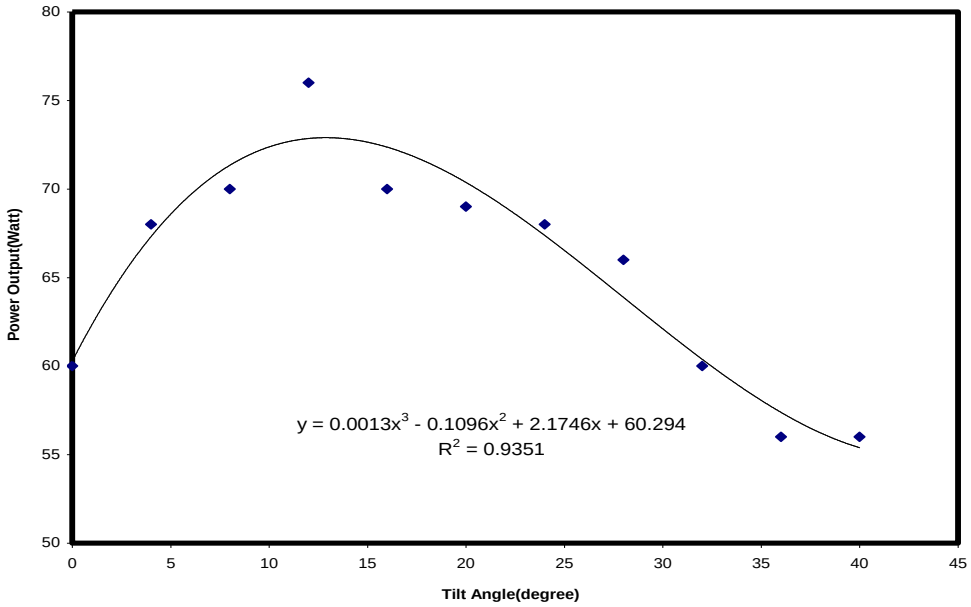

**Performance of PV Module at Different Tilt Angle (February)**



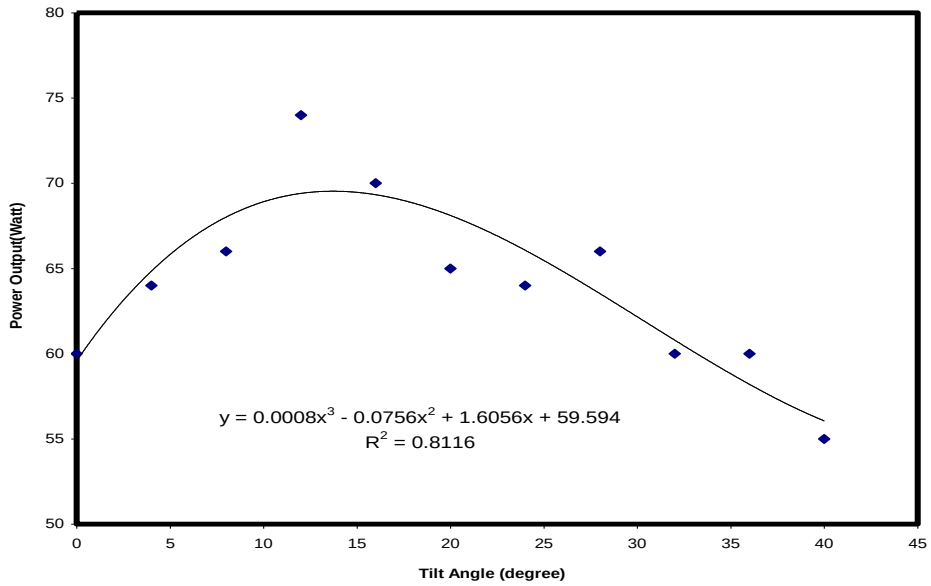

**Performance of PV Module at Different Tilt Angle (March)**



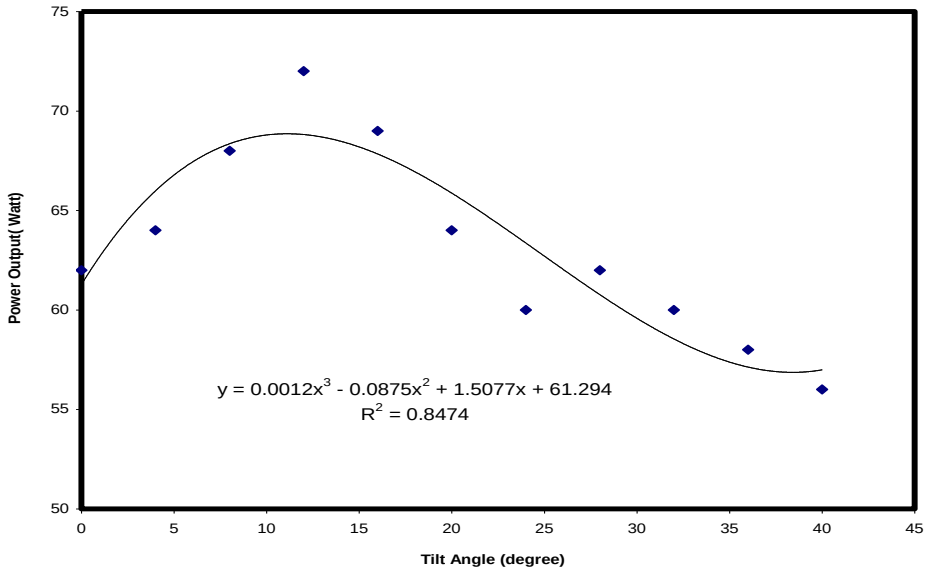

**Performance of PV Module at Different Tilt Angle (April)**



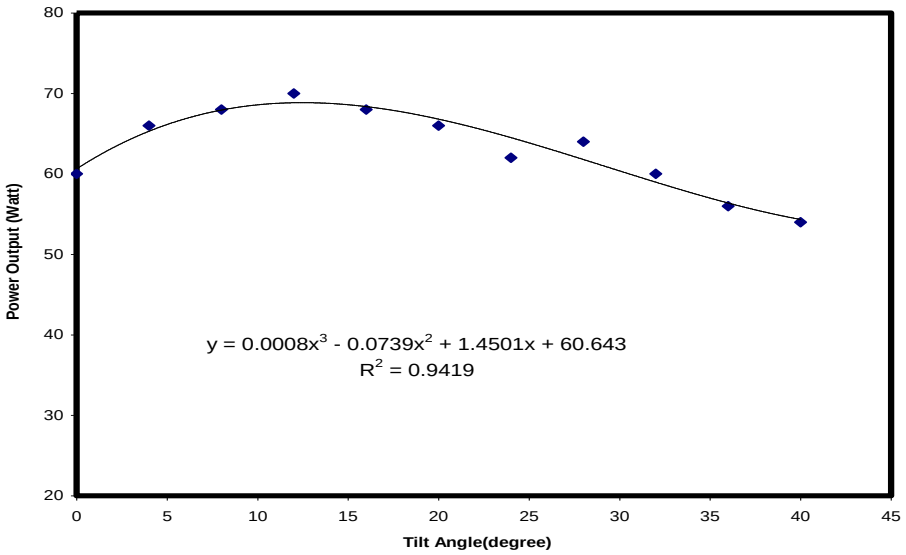

**Performance of PV Module at Different Tilt Angle (May)**



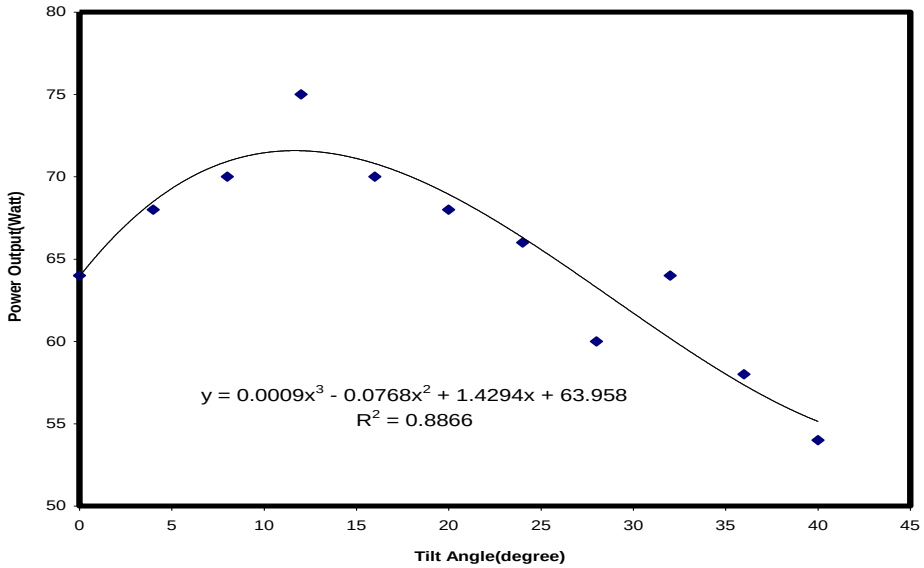

**Performance of PV Module at Different Tilt Angle (June)**




**Performance of PV Module at Different Tilt Angle (July)**




**Performance of PV Module at Different Tilt Angle (August)**




**Performance of PV Module at Different Tilt Angle (October)**

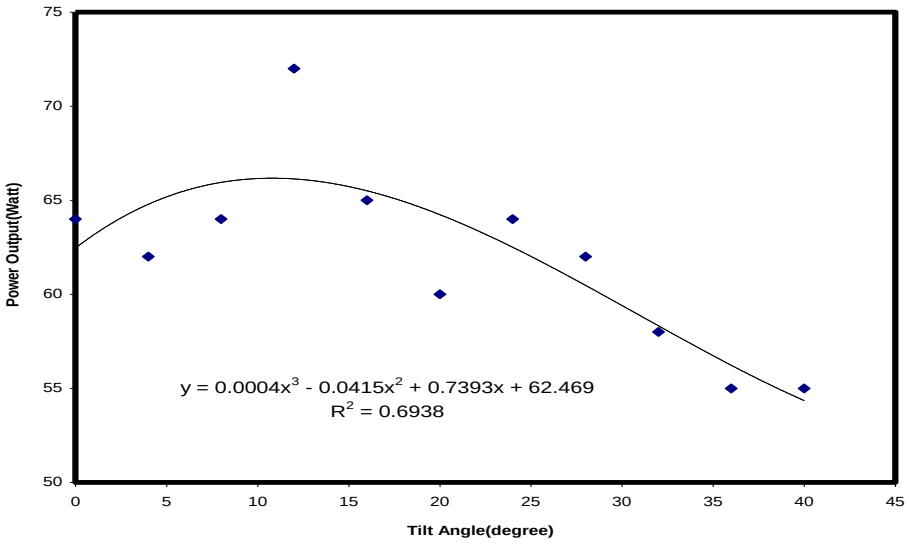
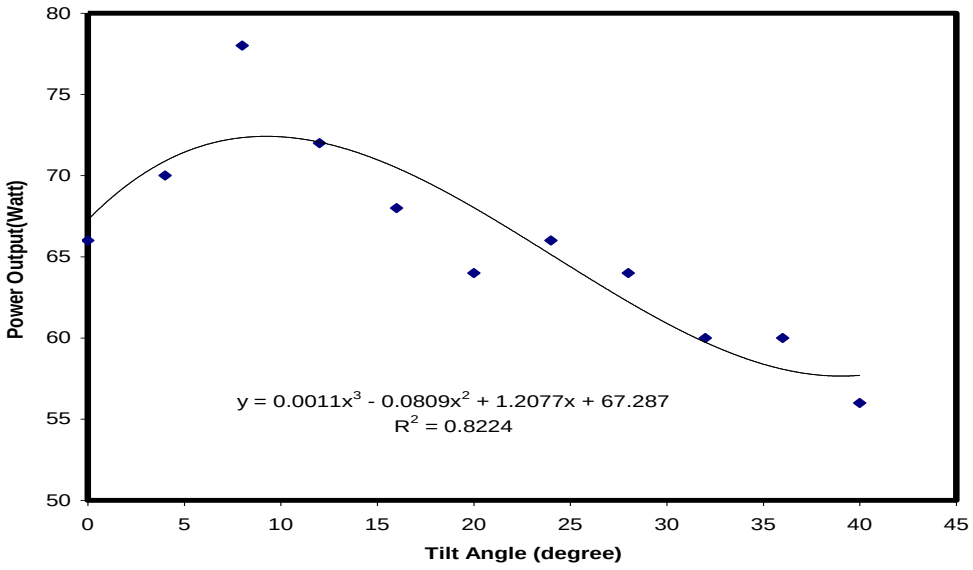
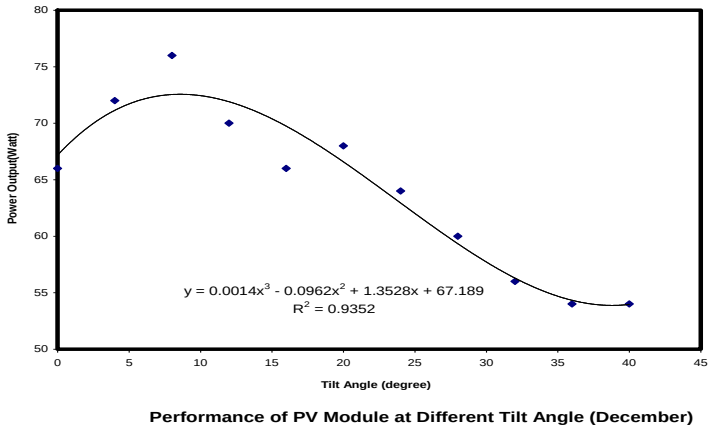



**Figure 3: Performance of PV system at Different Tilt Angle and Smooth Fitting of Data**






**Performance of PV Module at Different Tilt Angle (December)**

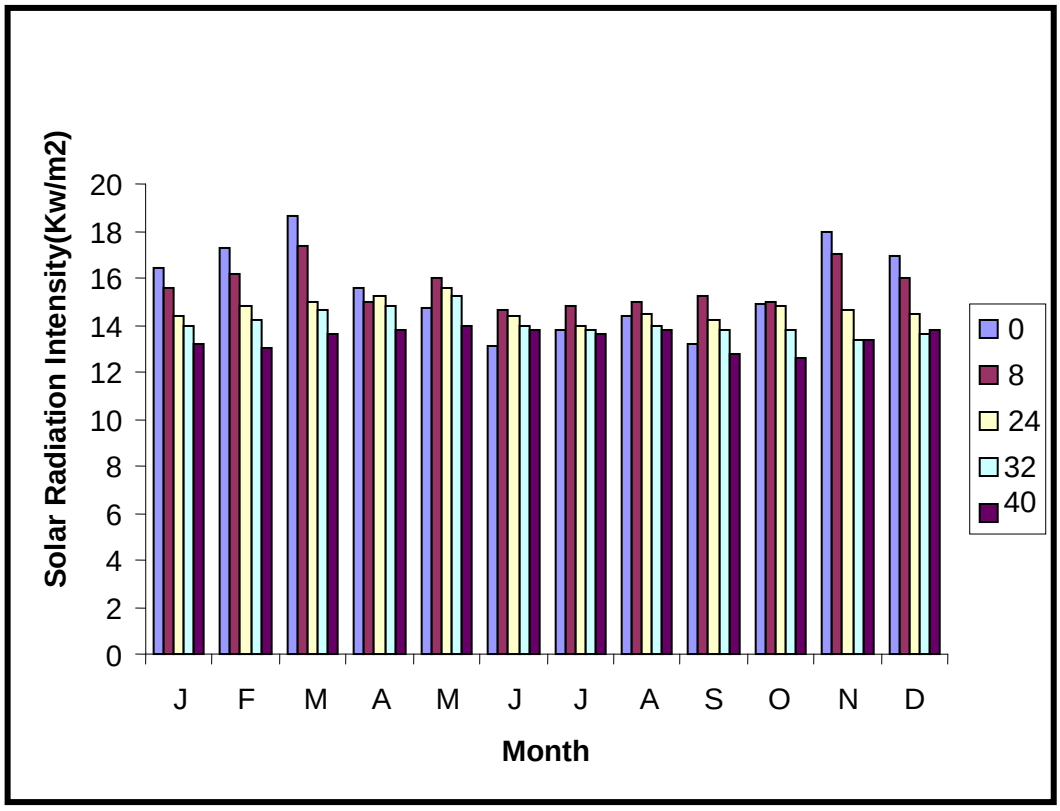



**Figure 2: Monthly Solar Intensity for Different Selective Tilt Angle**