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Solar Tracker in P.T.U E.P Department

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ABSTRACT
The main importance for this paper is that sixth year students can be used laptop and projector in presentation for their mini thesis though the light is off. As four 90W solar panel is connected in parallel, total power is 360W that is reliable for our loads. In this paper, the comparison between single axis and dual axis tracker radiation for Pyay District is expressed. Moreover, Ardunio program is applied for dual axis solar tracker. Myanmar is more suitable solar power to store energy in battery during sunny days as renewable.

KEYWORDS: *single axis, dual axis, solar tracker, reliable, Ardunio*

INTRODUCTION

Solar power in Myanmar has the potential to generate 51,973.8 TWh/year, with an average of over 5 sun hours per day. The country aims to generate 8% of electricity through renewable energy sources—through wind and solar energy—by 2021 and 12% by 2025. The weather is hottest from March-May among twelve months in Myanmar.

The following solar energy technologies can be successfully propagated: solar cookers; solar water heating systems for industrial application; solar distillation units for battery charging; solar photovoltaic systems for water pumping, battery charging, and power supply to children's hospitals for operating vital equipment. Solar air driers can be used for agricultural and industrial products.

Since Myanmar is a land of plentiful sunshine, especially in central and southern regions of the country, the first form of energy- solar energy could hopefully become the final solution to its energy supply problem. The direct conversion of solar energy into electricity using photovoltaic system has been receiving intensive installation not only in developed countries but also in developing countries.

It is mainly intended to present solar energy potential and application in Myanmar. It is also wanted to get the benefits of using solar energy for people in remote areas which are not yet connected to the national grids because of the high price of fossil fuel.

MEPE (Myanma Electric Power Enterprise) experimental measurements indicate that irradiation intensity of more than 5kWh/m²/day was observed during the dry season.

If solar panel is installed in fixed position, solar power can absorb when the sun faces with solar panel. Even single axis moves, the efficiency of solar power can prove by comparing with dual axis as sun orbit is changing all the year.

The overall block diagram for solar tracker in P.T.U E.P Department is shown in figure 1. After light dependence resistors had sensed where the sun is, the motors can move the solar panel due to Ardunio program. The battery either can store energy from solar during sunny days or can give supply when the rainy or cloudy days. The maximum 360 W loads such as laptop and projector can draw from solar tracker through inverter.

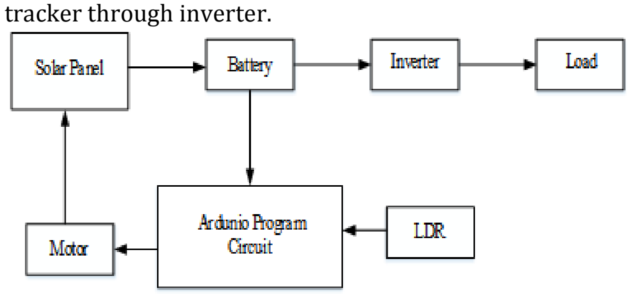

Figure1. The overall block diagram for solar tracker in P.T.U E.P Department

A. Solar Panel of Project

Since an individual cell produces only about 0.5 V, it is a rare application for which just a single cell is of any use. Instead, the basic building block for PV applications is a *module* consisting of a number of pre-wired cells in series, all encased in tough, weather-resistant packages. When photovoltaics are wired in series, they all carry the same current, and at any given current their voltage add as shown in Figure2. There are 36 cells in one PV panel to produce 18 V because one cell has 0.5V.

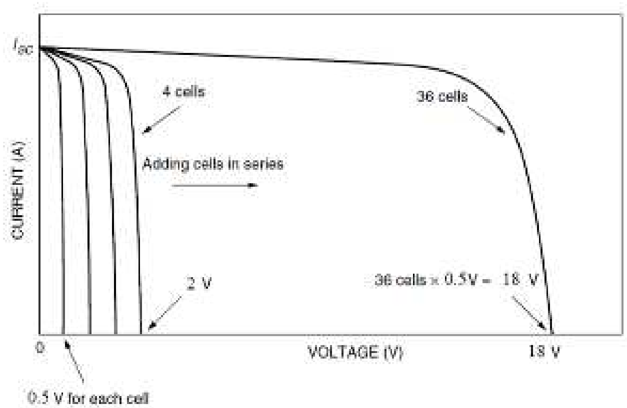

Figure2. For cells wired in series, this module will have 36 cells

By substituting equation 1, 2 and 3, the voltage and current of 90 W solar panel can be calculated assuming $R_p > 1\ \Omega$ and $R_s < 0.005\ \Omega$.

$$I = I_{sc} - I_0(e^{38.9V_d} - 1) - \frac{V_d}{R_p} \quad (1)$$

I_{SC} = short-circuit current,

I_0 = the reverse saturation current (A),

V_d = voltage across the diode terminals

R_P = parallel resistance,

$$V_{module} = n\,(V_d - I\,R_s) \quad (2)$$

R_S = series resistance,

$$P = V_{module} \times I \quad (3)$$

By combing many cells, one module becomes. The electrical specification for 90 W solar panel is expressed in Table 1.

Table1. The electrical specification of Solar panel

Maximum power, Pmax	90W
Maximum voltage, Vmp	18V
Maximum current, Imp	4.99A
Open circuit voltage, Voc	22.3V
Short circuit current, Isc	5.34A

Modules can be wired in series to increase voltage, and in parallel to increase current. In Figure 3, four solar module are connected in parallel so the current total value also reach nearly 20 A.

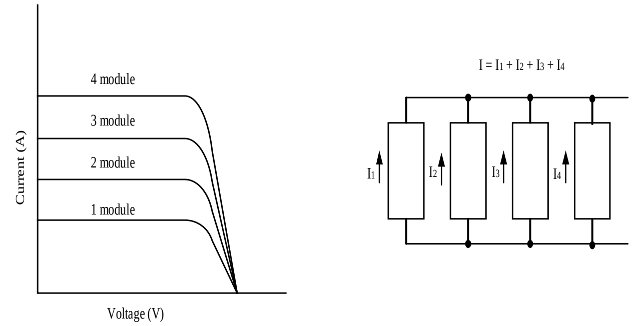

Figure3. For modules in parallel, voltage is the same but current will increase

B. Temperature and Solar Radiation in Pyay

Pyay is located in 18.8°N, 95.2°E Latitude and Longitude. Annual solar radiation of Pyay is 4.94kWh/m²/d. At an average temperature of 31.8 °C, April is the hottest month of the year. January is the coldest month, with temperatures averaging 23.5 °C.

$$T_{cell} = T_{amb} + \left(\frac{NOCT - 20^{\circ}}{0.8}\right)S \quad (4)$$

T_{cell} = cell temperature (C)
T_{amb} = ambient temperature (C)
NOCT = nominal operating cell temperature (C)
S = solar insolation (kW/m²)

From Equation 4, after cell temperature can get. As V_{OC} drops by 0.37%/ C and maximum power expected to drop about 0.5%/ C, it is about 16 % drop of rated power.

Average temperature (°C) and Daily Solar Radiation Horizontal (kWh/m²/d) of Pyay are expressed in Table 2. Even in cold season, power is nearly about 76W. As April is hot season, solar radiation is the most among other months.

Table2. Average temperature (°C) and Daily Solar Radiation Horizontal (kWh/m²/d) of Pyay

Month	Average Temperature (°C)	Daily Solar Radiation Horizontal (kWh/m²/d)
January	23.5	5.26
February	25.5	5.90
March	29.3	6.44
April	31.8	6.60
May	30.9	5.31
June	28.2	3.78
July	27.4	3.82
August	27.6	3.73
September	28	4.36
October	27.9	4.59
November	26	4.64
December	23.5	4.88

C. Sun Path of Pyay

The sun's position can be described by its altitude angle β and its azimuth angle φ_S. Altitude angle and azimuth angle is drawn in Figure 4.

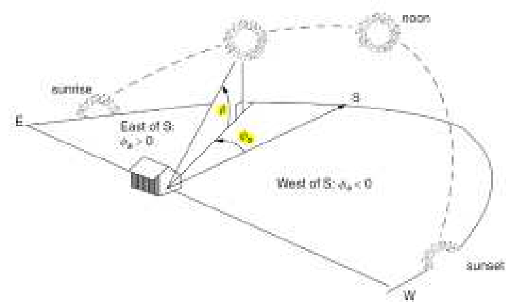

Figure4. The sun's position can be described by its altitude angle β and its azimuth angle φ_S.

$\sin\beta = \cos L \cos\delta \cos H + \sin L \sin\delta$ (5)
β = altitude angle of the sun
δ = solar declination
L = the latitude of the site
H = hour angle

$$\sin\varphi_s = \frac{\cos\delta \sin H}{\cos\beta} \quad (6)$$

φ_S = azimuth angle

By substituting Latitude of Pyay in Equation 5 and 6, sun path of Pyay can be calculated.

D. Dual Axis Tracking System

Dual axis tracking system can move East and West and North and South as not same as single axis. Total power 360 W can produce by connecting parallel four 90 W solar panel. This Figure can be seen in Figure 5. The length and width of one 90 W panel is 4́ (4 Feet) and 21́′(21 Inches) so total measurement is 7 (7 Feet) and 4́ (4 Feet).

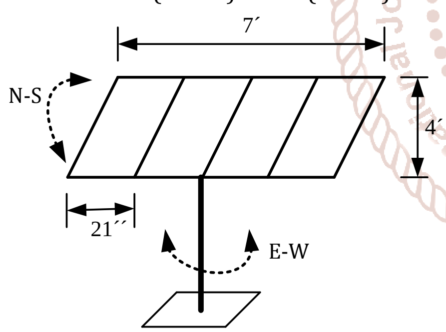

Figure5. Dual Axis Solar Panel in P.T.U E.P Department

Moreover, dual axis tracking system is more efficient than single axis tracking system. Trackers are described as being either *two-axis trackers*, which track the sun both in azimuth and altitude angles so the collectors are always pointing directly at the sun, or *single-axis trackers*, which track only one angle or the other. It can be proved that by using the following Equations.

Two-Axis Tracking
$I_{BC} = I_B$ (7)
I_{BC} = beam insolation on collector
I_B = beam insolation at earth's surface

$$I_{DC} = CI_B\left[\frac{1+\cos(90^\circ-\beta)}{2}\right] \quad (8)$$

I_{DC} = diffuse insolation on collector
β = solar altitude angle
One-Axis
$I_{BC} = I_B \cos\delta$ (9)

$$I_{DC} = CI_B\left[\frac{1+\cos(90^\circ-\beta+\delta)}{2}\right] \quad (10)$$

Total rate at which radiation strikes a collector I_C can be gotten by summing beam insolation I_B and diffuse insolation on collector I_{DC}. I_C of two axis tracking is 1015W/m^2 and I_C of one axis is 928 W/m^2 by substituting above equation 7,8,9 and 10. Therefore, dual axis is 9% higher than the single-axis mount.

E. Ardunio Program

To rotate dual axis, Ardunio program is applied in this paper. There are four pins for output and four sensors for East, West, South and North. There are two motors for moving. We need to command the circuit the following program.

```
int k=80;//tolerance

void setup()
{
pinMode(2,OUTPUT);
pinMode(3,OUTPUT);
pinMode(4,OUTPUT);
pinMode(5,OUTPUT);
}
void loop()
{
int val1=analogRead(A0);//Sensor1 for East
int val2=analogRead(A1);//Sensor2 for West
int val3=analogRead(A2);//Sensor3 for South
int val4=analogRead(A3);//Sensor4 for North
int Ref=analogRead(A4);//Reference Voltage
if(val1>(val2+k)&&val1<Ref&&val2<Ref)
{
digitalWrite(2,HIGH);//motor1 for Forward
digitalWrite(3,LOW);
}
if((val1>val2&&val1<(val2+k)&&val1<Ref&&val2<Ref)||(val
2>val1&&val2<(val1+k)&&val1<Ref&&val2<Ref))
{
digitalWrite(2,LOW);//motor1 for Stop
digitalWrite(3,LOW);
}
if((val2>(val1+k)&&val2<Ref&&val1<Ref)
||(val1>=Ref&&val2>=Ref))
{
digitalWrite(2,LOW);
digitalWrite(3,HIGH);
}
if(val3>(val4+k)&&val3<Ref&&val4<Ref)
{
digitalWrite(4,HIGH);
digitalWrite(5,LOW);
}
```

```
if((val3>val4&&val3<(val4+k)&&val3<Ref&&val4<Re)||(val4>val3&&val4<(val3+k)&&val3<Ref&&val4<Ref))
{
digitalWrite(4,LOW);
digitalWrite(5,LOW);
}
if((val4>(val3+k)&&val4<Ref&&val3<Ref)||(val3>=Ref&&val4>=Ref))
{
digitalWrite(4,LOW);
digitalWrite(5,HIGH);
}
}
```

Result

Finally, we can choose the battery and inverter rating for loads and solar panel. Solar panel is four 90 W and its voltage and current are 18 V and 20A. The more energy can be stored in the 12 V, 120 Ah battery by tracking solar panel and its charging time is 6 hr. This DC voltage can change to AC voltage through inverter. The rating of inverter is 500 W and 40 A fuse rating is chosen. The main aim of this project is that to use the laptop and projector in the Department of Electrical Power in Pyay Technological University when the light is off. The power of laptop and projector are 60W plus 282 W. So, the total load is about 342 W that is reliable with solar.These ratings are inserted in Table.

Table3. The Ratings of Overall the Project

Components	Specification
Solar Panel	90 W, 5A , 4 panel parallel 360 W , 20 A , 18 V
Battery	Choose 12V, 120 Ah Battery 20A , 6 hr charging
Inverter	360W×0.2(safety margin) = 72 W 360W + 72W = 432 W Choose500W, 12V~230V 500W/ 12 V = 41A 40A fuse
Load	Laptop14-15in = 60 W Projector EPSON EBW05 = 282 W Total = 342 W

To rotate solar panel, we require the altitude and azimuth angles. The result of these angles is drawn with Matlab program in Figure 6.

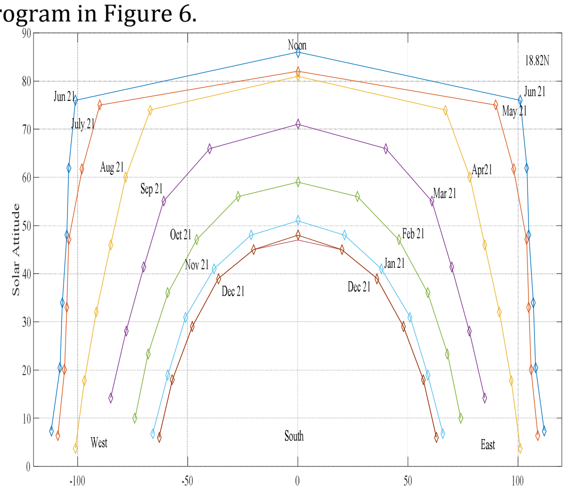

Figure6. Sun Path Diagram Showing Azimuth and Altitude Angles for 18.82° Latitude (at Pyay)

An inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The square wave inverter is one of the simplest waveforms among others such as pure sine wave inverter, modified sine wave inverter and is best suited to low-sensitivity applications such as lighting and heating. To supply AC load, inverter is required and Figure 7 is simulation result of square wave output of inverter. The straight line with blue color is DC 12 V and the square wave with red color is for output 230 V. Square wave is used when the electricity has a constant force, such as it has with DC but switches direction more or less instantly at the same kind of frequency as the normal grid supply (at 50 times per second).

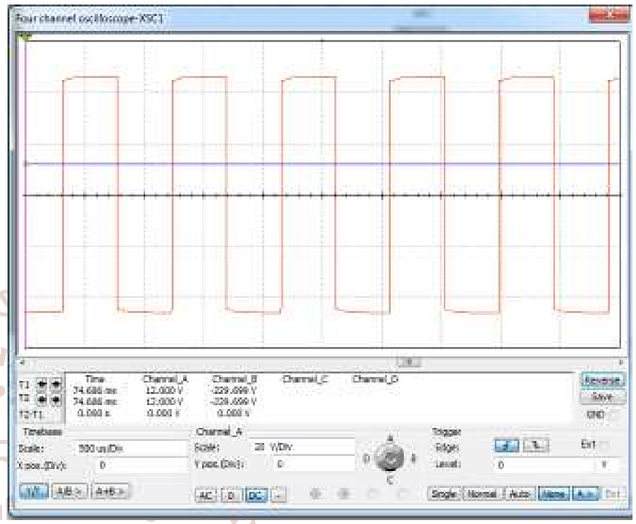

Figure7. Simulation Result of Square Wave Output of Inverter

Recommendations

As this solar tracker is only functional, we have many plans to continue this project. We can draw this circuit in Proteus software. We can substitute DC motor with stepper motor to be very definite by giving PIC program. The stepper motor can move step by step very detail. We can add charge controller circuit and the circuit to overcome for battery overcharging. Moreover, we can collect more data with measuring instruments with time schedule such as daily, monthly and yearly. We should consider how much cost effective and energy efficiency by comparing 360W fixed solar panel and equal power dual axis.

Conclusion

In Myanmar, renewable energy especially solar power is applied in many villages without connecting National Grid. But, they are mostly installed in fixed position. Dual axis solar tracker is very less when comparing fixed position. This project is very useful because we can give presentation even there is no electricity or the light is off. As four 90W solar panel are connected in parallel, laptop and projector can cover from this 360W solar panel. Pyay can get the efficient solar radiation so solar power is very suitable in this place.

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