Design and Analysis of enhancement of Solar PV efficiency with Aluminum sheet reflection

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***Abstract*: The Photovoltaic efficiency can be increased by using Aluminum sheet reflected light on PV panel, but if panels were exposed to concentrated sunlight through reflector may get damaged due to rise in temperature of silicon cell. It is necessary to simultaneously to control temperature as well as the enhancement of output. An experiment was conducted on a designed system and observations were used to study the effect of reflected sunlight on the PV output voltage. This paper covers the discussion on the observation so obtained and as well designed system built was highlighted. By performing the said experiment we were able to increase panel efficiency up to Maximum of 45%. Also future scope of cooling system is mentioned in the paper.**

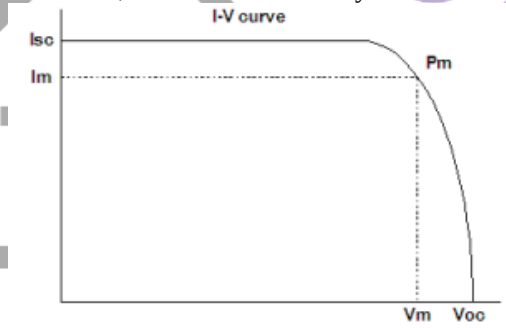
***Index Terms*: Arduino-uno, Solar Aluminum reflector, Solar efficiency, Stepper motor, Enhancement of efficiency**

I. INTRODUCTION

THE fundamental need of today's time is energy. As blood is to body energy is to economy for any country. Nonrenewable resources are either too expensive or damaging our environment and hence finding solution new energy sources and optimization of available energy is the main issue in front of us. That's why we are now tending towards renewable sources of energy on a larger scale. Though hydro-electricity is cheap, but it has geographical limitations while solar power has bright potential on that front [1].

II. BACKGROUND THEORY

The characteristic of solar cell can be description by curve has shown be relation current and voltage of solar cell (IV-Curve) which the solar cell curve can be show 3 types the cell side, module side and array side use to this curve show in figure



-Maximum current value (Im) is the maximum current of solar cell with load.
- Maximum voltage value (Vm) is the maximum voltage of solar cell with load.
- Short-circuit Current value (Isc) is the current of solar cell short circuit
- Open-circuit Voltage value (Voc) is the voltage of solar cell short circuit without load.
- Maximum power value (Pm) is the maximum power output of solar cell without load.
- Fill Factor value (F.F) is ratio of the maximum power to the Current short circuit value multiple the voltage of solar cell short circuit with show that equation (1).

$$F.F = \frac{\text{Pm}}{\text{Isc x Voc}} \qquad \text{.....(1)}$$

The solar cell should be has field factor more than 0.7 for the maximum efficiency of power. Maximum Efficiency (ήm) is ratio of maximum power to total output power of solar cell so that equation (2)

$$\text{ήm} = \left[\frac{\text{Pm}}{\text{Am x Gt}}\right] \text{x } 100\% \qquad \text{.....(2)}$$

where Am = area solar light
Gt = intensity of solar light.[2]

Figure 1 shows characteristics of relation between current and voltage of solar cell

III. The Laws of Reflection

A light ray is a stream of light with the smallest possible cross-sectional area. (Rays are theoretical constructs.) The incident ray is defined as a ray approaching a surface. The point of incidence is where the incident ray strikes a surface. The normal is a construction line drawn perpendicular to the surface at the point of incidence. The reflected ray is the portion of the incident ray that leaves the surface at the point of incidence. The angle of incidence is the angle between the incident ray and the normal. The angle of reflection is the angle between the normal and the reflected ray [2].

- The angle of incidence is equal to the angle of reflection.
- The incident ray, the normal, and the reflected ray are coplanar.

Specular reflection (regular reflection) occurs when incident parallel rays are also reflected parallel from a smooth surface. If the surface is rough (on a microscopic level), parallel incident rays are no longer parallel when reflected. This results in diffuse reflection (irregular reflection). The laws of reflection apply to diffuse reflection. The irregular surface can be considered to be made up of a large number of small planar reflecting surfaces positioned at slightly different angles. Indirect (or diffuse) lighting produces soft shadows. It produces less eye strain than harsher, direct lighting. $\theta i = \theta r$ [3].

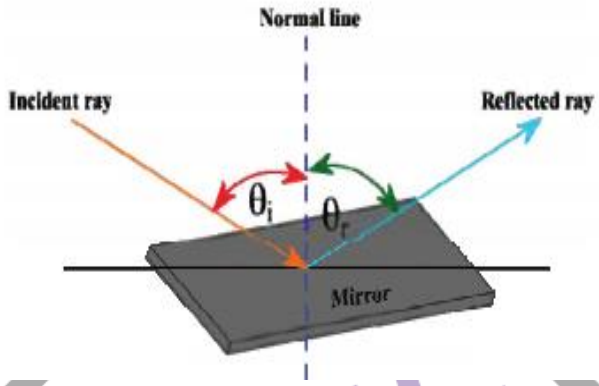


Figure 2 shows reflection of light by reflector

IV. Experimental Setup

The proposed model is for improving solar panel efficiency which is based on the experimental dated (readings and graphs). All the recorded readings are from the month of May 2019 for seven different days. A polycrystalline solar panel made from silicon semiconductor is used for the experiment. Iron made frame for PV panel, reflector (Aluminum sheet) and stepper motor was designed. For Automated motion of reflector (Aluminum Sheet) Arduino-Uno controller is coupled with stepper motor is used to illuminate PV panel more effectively with sunlight [3].

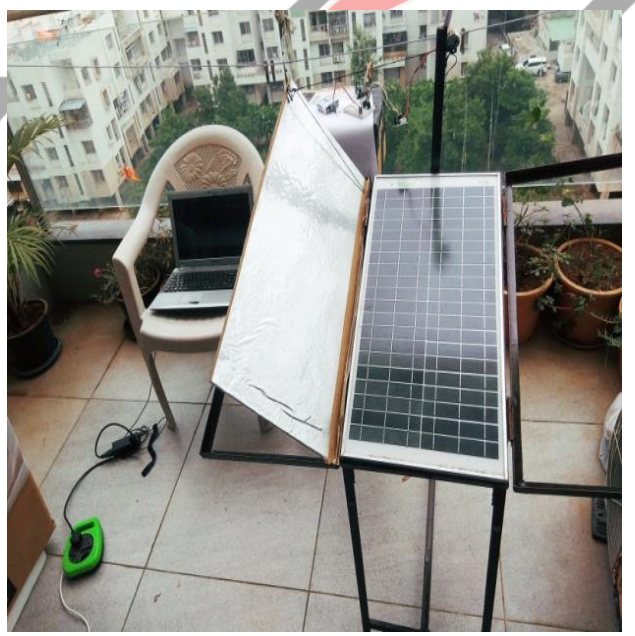


Figure 3 Actual hardware setup

According to the setup from morning to afternoon the Reflector will reflect the sunlight on the panel. Its alignment is controlled by stepper motor controlled by micro-controller to cope up with sun's trajectory as time passes.

A. Components and Specification

A.1 Solar Panel

Figure 4 shows Solar panel used

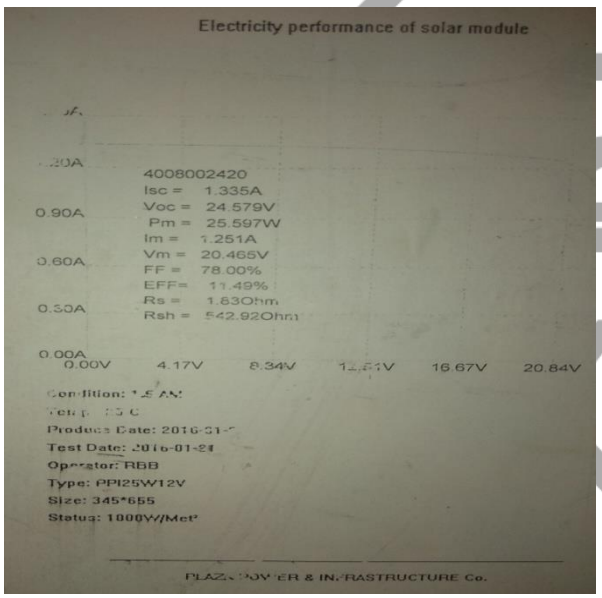


Figure 5 Data sheet of the panel

A.2 Arduino Uno

Micro-controller Arduino uno At mega 328 Specifications		
S.no	Parameter	Rating
1	Operating voltage	5 V
2	In-put Voltage(recommended)	7.12 V
3	In-put Voltage(limit)	6.20 V
4	DC current per output pin	40 mA
5	DC current for 3.3V pin	50 mA
6	Clock Speed	16 MHz

A.3 Stepper Motor

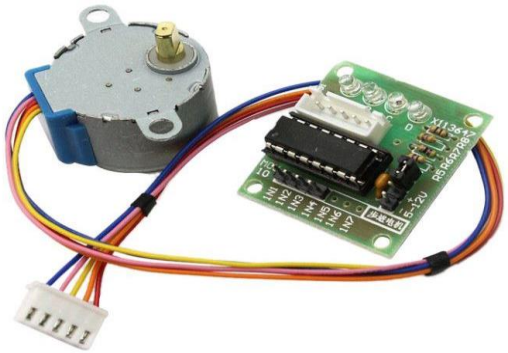


Figure 6 shows 28byj-45 Stepper motor

A uni-polar 28BYJ-48 stepper motor is coupled with ULN2003 driver for micro-stepping and motor control. This motor is used to control motion of aluminum reflector.

B. Experiment Methodology

Sunlight is the morning and evening are in the diffused state which does not give the desired result. If we could direct the sun rays in the morning and evening hours with the help of reflector on to the panel, output increases. The panel is placed in north-south direction tilted at 19 degrees as per the geographical location. Morning sunlight is directed on it with the reflector (Aluminum sheet) and as the time passes and sustained reflection reflector rotates to provide more and more of sun's illumination [6][9][10].

TABLE I

Observation 1 output without reflection

Conventional output voltage			
Date	**Time (am)**	**Ambient Temperature** in degree celcius	**Output voltage(Voc) in volts**
3/5/19	8.35	23	19
	8.40	23	17.6
	8.45	23	22
	9.00	23	22.1
	9.10	23	22.5
5/5/19	8.30	28	22.3
	8.46	28	22
	9.05	28	22.3
	10.40	32	23.7
	11.10	34	22
6/5/19	7.00	24	21
	7.10	24	21.2
	7.30	24	21.6
	8.20	27	22.1
8/5/19	7.00	24	21.1
	7.20	24	21.9
	8.30	24	22.3
	9.10	28	22.2

Tables II

Observation 2 output with Reflection [4].

Comparison of output with and without reflection				
Date	Time (am)	**Ambient Temperature** in degree Celsius	Output voltage(**Voc**) volts **without reflection**	Output voltage(**Voc**) in volts **with reflection**
10/5/19	7.10	23	21.3	23
	7.30	24	21.8	23.2
	8.00	26	22.2	23.2
	8.30	27	22.3	23.2
	8.45	27	22.2	23
	9.00	28	22.1	22.9
	9.25	28	22.0	22.5
13/5/19	6.10	24	15.7	16.9
	6.30	24	18.5	20
	6.45	24	20.2	21.9
	7.00	24	20.7	22.4
	7.15	25	20.3	22.7
	7.30	25	21.7	22.9
	7.45	26	21.9	22.9
	8.00	26	21.9	22.8
	8.20	27	22	22.8
	8.40	27	22.1	22.8
	9.10	29	21.9	22.5
14/5/19	6.15	24	18.6	20.6
	6.30	24	20.3	22.2
	6.45	24	20.9	22.8
	7.03	24	21.5	23.0
	1.18	25	21.7	22.3
	7.33	25	22.0	23.2

TABLE I

Observation 3 output comparison

Comparison between the readings				
date	Avg value of output voltage **without reflection**	Avg value of output voltage **with reflection**	Diff in the reading	% efficiency increase
10/5/19	15.8	23	7.2	45.5
13/5/19	17.5	21.8	4.3	24.9
14/5/19	20.8	22.35	1.55	7.4

V. CONCLUSION

It is seen from the experiment that the Solar panel output voltage (Voc) increases due to more and more reflection throughout the day. But it is also noted that due to sustained reflection on the solar cell, cell temperature also increases. This in turn tries to reduce its efficiency and hence cell temperature has to be maintained within the data sheet values of the panel [7].

VI. FUTURE SCOPE

The variation the temperature value can be controlled by cooling techniques. Temperature if maintained by cooling will further increase the panel efficiency [8].

REFERENCES

[1] Shahjahan Ahmed, Mohammad Mahmudul Alam Miya, "More efficient use of Photovoltaic solar panel using multiple fixed directed mirror or aluminum foil instead of solar tracker in rural perspective of Bangladesh," International journal of Scientific & Technology Research vol 3,issue 4, April 2014.

[2] S.Julajaturasirarath, W.Jonburom," The experiment of double solar energy by reflection method," Sciverse Science Direct, 25 November 2011.

[3] Johan Nilsson," Optic Design and Characteristics of solar concentration for Photovoltaic," Division of energy and building design, Department of Architecture and built environment, Lund University Malmo, Scandinavia, 2005.

[4] CH Srisailam, T. Srihari," Improvement of solar energy by mirror reflection technique," International journal of engineering research and general science vol3, issue 3, May 2015.

[5] Lzar Lopez Ramizer,"Operating correction factor of PV system, Effect of temperature, angle of incidence and inverter in PV system performance," University of Glave, January 2017.

[6] Pradeep Sigh," Design, Facbrication and experimental Analysis of automatic solar tracking system for parabolic Trough collector for hot water generation," Thapar University, Patiala, India, July 2013.

[7] Rizwan Arshad, Salman Tariq," Improvement of solar panel efficiency using solar concentration by simple mirrors and cooling," IEEE conference on robotics and emerging Allied technologies in engineering, April 22 2014.

[8] Oumaima Bendra," Otimizing Solar cells efficiency by cooling Technique," AL Akhawayn University In Ifrane, School of Science & Engineering, 2017.

[9] Matelot," ULN2003 board and Stepper motor 28BYJ-45, November 2017, https://forum.arduino.cc/index.php?topic=511367, accessed March 2019.

[10] Nikodem Bartrik," 28BYJ-48 Stepper motor and ULN 2003 Arduino quick tutorial for begineers, June 2018, https://www.youtube.com/watch?v=avrdDZD7qEd, accessed April 2019.