CONVERGENCE TUNING OF SOLAR POWER FOR ENHANCED ENERGY HARVESTING

S. K. LAHA†, P. K. SADHU‡, A. GANGULY§ and A. K. NASKAR†

† *Department of Electronics & Communication Engineering, Techno India Batanagar, Kolkata-700141, India*
Email: sumanlaha88@gmail.com, naskar73@gmail.com
‡ *Department of Electrical Engineering, Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand-826004, India. Email: Pradip_sadhu@yahoo.co.in*
§ *Principal, Techno India Batanagar, Kolkata-700141, India. Email: anksjc2002@yahoo.com*

***Abstract* –There is a crucial need for sustainable progress in the field of energy saving in rational time. This paper shows the effect of solar energy in photovoltaic with a Fresnel convex Lens. With the use of this Lens it has been studied that there is unbelievable improvement in various parameters of photovoltaic nature. With the use of the Fresnel lens the concentration of the system has been enhanced in commendable time. In order to diminish the losses from reflection, proper photon management has been implemented. This paper describes an approach in scheming of concentrator module. Small size sub-module ,each of which 2×2 cm^2 aperture and 15cm focusing distance are united in a fully hermetic module which is resistance to the environmental effects. Fresnel's Lens has a composite construction and comprise of a silicate glass and a thin refractive profile made of transparent silicon. These advances concern the two main mechanisms of the system, the optics and the cell, as well as their mixing inside a complete module. The projected system can help in reducing the dependency by fossils fuel in the environment.**

***Keywords* – Solar energy, Fresnel convex lens, Concentrated photovoltaic, Condensed light, Proportional study, Increased energy.**

I. INTRODUCTION

The foremost benefit of the concentrator concept is the reduced cost of the concentrator optics related to solar cell. The first concentrator modules were formed and tested in the late 20th century in USA (Dabirian *et al*., 2017; Ferrada *et al.,* 2017). At the same period, an independent research and expansion center of concentrator module was formed at the Loaf Institute in the former Soviet Union. After that PV concentrator module and an installation with huge area Fresnel lens were planned and fabricated as well. In the late 1980's-early 1990's a changed methodology to the module design was established in the Loaf Institute and Fraunhofer ISE. It involved in a dramatic minimization technique of geometrical dimensions of sub modules with Lens concentrator with taking care of a high concentration ratio (Kruse *et al*., 2017; Cappelletti *et al.*, 2016). The main benefits of the minor size sub modules are the followings:

- Small size solar cell will be useful as lower ohomic losses
- There is no necessity in compensation technique of thermal growth difference among materials of SC and the heat sink.
- The module thickness will be in condensed formed.
- By doing the smaller focusing distance of the concentrator, lower feeding of the module hosting material can be done.
- There is a huge opportunity to apply for module manufacturing high efficiency industrial methods used in electronic component production for industrial and home appliances.
- Huge chance to project a fully hermetic concentrator PV module for the beneficial of the society.

Looking at all the scenario, the main task is how to incorporate the Fresnel lens to increase the efficiency, power of a solar cell by increasing the concentration of photon in a particular area. Higher concentration of solar energy can be achieved by using array of Fresnel lens. This arrangement can help to reduce the losses and meet the demand of affordable price. It helps in minimizing in dependency on energy from fossils fuel. The main aim is to develop a system which can be renewable and bearable for a long term action. The main theme of this projected methodology is to diminish the time of charging, manufacturing cost, installation cost and make it reasonable for the entire use for everybody of the society (Andreev *et al.,* 1992; Blieske *et al.,*1994; Cristaldi *et al.,*2014). This modified paper defines the progress in the field of advanced lens based concentrator module with improved structure and advancement of solar simulators for the use of indoor characterization of both module components and accumulated modules characteristics. Here also the indoor measurements results and data are given for experimental modules prepared with high efficiency act. Conversion efficiency and power has been measured in indoors in a test module using a fresh established small-area solar simulator.

II. LITERATURE REVIEW

Since many years researchers are trying to enhance the efficiency and power of solar photovoltaic devices by many intent ways. Therefore, many ways have been adopted so as to decrease the reliability on energy by fossils fuels in time to time. Sharma and Punetha

(2016) proposed a noble approach to increase the efficiency with the combined effect of solar energy, nanotechnology and Fresnel convex lens. With the help of these three combined characteristics they have improved the concentration of the total system (Sharma and Punetha, 2016). Mohammadirad and Nagasaka (2014) shown that with the help of Fresnel condenser lens the power generation can be improved of the solar photovoltaic and it will be cost effective too so that the modified system can be applied in both domestic as well as commercial purpose. Madhugiri and Karake (2012) mainly focused in solar energy concentration with changing the value of temperature with the help of parabolic solar concentrator, Fresnel lens, reflecting materials and solar tracker. They have significantly increased the level of performance of the solar photovoltaic with their modified technique (Madhugiri and Karake, 2012). Wagenpfahl *et al*. (2010) elaborately depicted that with considering the effect of reduced bulk recombination and with finite surface recombination velocities how the power transformation efficiency changes. Thorough this technique they have clearly shown how the mobility optimization is an important parameter for the performance variance in solar cell arena (Wagenpfahl *et al.*, 2010). Sarsama *et al*. (2015) efficiently shown in their article that how by using the nanofluid particle the efficiency, thermal performance and thermal conductivity of a solar collectors can be increased by properly managing the energy flow of the solar collector via heat transfer. Ghassoul (2013) have projected a system for enhancing the power with automatic solar tracking module. By using this technique, they have shown an automatic tracking mechanism of sunlight through which the position changing nature of the sun can be identified. According to the daylight intensity their solar panel automatically move towards the sun where it gets the maximum power (Ghassoul, 2013). Lenert *et al*. (2014) concluded a nanophotonic and high performance solar thermo photovoltaic energy translation. The device customs carbon nanotube absorber to absorb maximum sunlight into it (Lenert *et al.*,2014). Jihun *et al*. (2012) proposed a new method of carrier control recombination process by changing the junction doping concentration of nanostructures materials. Through which they have shown how to enhance the charge carrier recombination and increases the nature of efficiency in solar photovoltaic (Jihun *et al.*, 2012). Terao *et al*. (2002) proposed recent developments on the flat plate micro concentrator module where they have demonstrated the condensed light process by a non-imaging optical design based on compact total internal reflection. Through this method they have proclaimed how the efficiency of the solar photovoltaic is increasing (Terao *et al.*, 2002). Jaus *et al*. (2009) suggested new development of Flacton modules using secondary optics by which they have shown the efficiency and power of the solar photovoltaic is increasing significantly (Jaus *et al.*, 2009).

III. REQUIRED DESCRIPTION

The solar energy is the heat and light emitted from sun and it is limitless for human use. It's entirely up to us how we make its use in a productive manner for our daily use, with the help of different technologies like solar heating, photovoltaic, solar thermal energy and even artificial photosynthesis etc. This are all good satisfactory option as the energy from sun is renewable. It will help to reduce the pollution that is caused by the fossil fuels like coal, petrol, diesel etc. A proper arrangement is to be made to absorb the solar energy and convert it into anticipated form of electrical power (Arya *et al.*, 2015; Ghosal *et al.*, 2014). Solar power is the transformation of sunlight into electricity either by Photovoltaic or by Concentrated Solar Power (CSP).

$$E = h\, f \tag{1}$$

where E is energy of photon, h is Planck Constant and f is the frequency of photon (Navjeet *et al.*, 2015; Dimroth *et al.*, 2014). Photovoltaic changes sunlight into electric current by photoelectric effect while CSP uses lenses or mirrors to concentrate sunlight into a focused beam in a particular portion. Solar energy can be harnessed extreme in places like desert areas. Since the intensity of sunlight is mostly in desert areas. Thus, the energy can be kept in Thermal Mass System Energy Storage, Phase change material Grid Energy Storage like rechargeable batteries etc. Therefore looking at the cumulative demand of people there is an urgent requirement that some revolution is presented in the market which would be helpful for the people and also for the governments which are trying to handle the huge pollution cause by the fossil fuels. The use of appropriate lenses or mirrors can be done for suitable focusing or concentrating light at the particular area. The energy can be kept for future use

$$\eta = V_{OC}\, \frac{I_{SC} FF}{P_{in}} \tag{2}$$

where V_{oc} is the open circuit Voltage, I_{sc} is the short circuit current, FF is the Fill Factor and η is the efficiency of solar cell (Ciani *et al.*,2015; Soto *et al.*, .2006)

Fresnel Lens:

Fresnel lens is helpful for focussing the sunlight in a particular area. It can focus sunlight onto solar cells. This effect is shown in Fig. 1. Therefore, the solar cell surface can be condensed thus making the small size. Fresnel reflectors are cast-off in concentrating solar power plants to concentrate the solar energy. It would help in carrying increase in the output. The solar along with Fresnel lens will carry the incredible increase in the output voltage which can be used consequently (Kuo and Lo, 2014; Ziar *et al.*, 2014; Wacaser *et al.*, 2015).

The absorption of radiation over a homogeneous medium is specified by Beer-Lambert law

$$A = -\log T \tag{3}$$

where $A = abc$, $T = I_1/I_0$, a is absorption coefficient, b is path length of light, c is the concentration, I_1 is the emerging light, I_0 is the intensity of light.

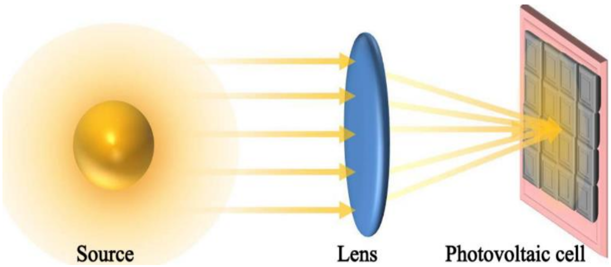

Fig. 1: Fresnel's Lens effect on solar photovoltaic.

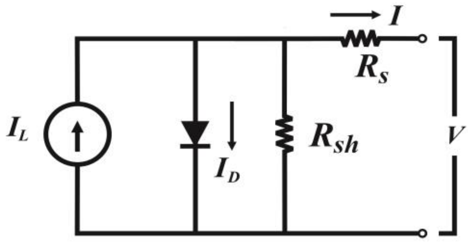

Fig. 2: Single diode structure of solar cell.

The most significant part among all of this is the photon management striking in the solar cells. In order to decrease the losses from reflection, photons released must be managed appropriately. If the photons accurately strike in the solar cell and absorbed completely by it and if there is no further reflection then the photon management will be accomplished and the output will also be improved. Since the losses are reduced, it will help to raise the charge carrier recombination. As a result, more photons are absorbed and efficiency will be increased in a fruitful way (Xu *et al.*, 2013).

I-V Equation of PV cell: Overall mathematical explanation of I-V output characteristics for a PV cell has been considered for over the past four decades (Shukla *et al.*, 2015). The PV cell is generally represented by the single diode model. The single diode equivalent circuit of a solar cell is shown in Fig 2.

The I-V characteristics equation of solar cell (Moya *et al.*, 2015) is given as follows:

$$I = I_L - I_0\left\{e^{\left[\frac{q(V+IR_s)}{AkT_c}\right]-1}\right\} - \frac{(V+IR_s)}{R_{sh}} \quad (4)$$

where I_L is a light produced current or photo current (demonstrating the current source), I_0 is the saturation current (representing the diode), R_s is series resistance, A is diode ideality factor, k (= 1.38 ×10^{-23} W/m^{2}K) is Boltzmann's constant, q (=1.6×10^{-19}C) is the magnitude of charge on an electron and T_C is working cell temperature. Photo current or light generated current, mostly depends on the solar insolation and cell working temperature, which is defined as:

$$I_L = G[I_{SC} + K_I(T_C - T_{REF})] \quad (5)$$

where I_{sc} is the short circuit current at 25°C and with a constant value of irradiance of 1kW/m^2, K_I is the short circuit current temperature coefficient, T_{REF} is the reference temperature and G is the solar insolation kW/m^2, on the other part, the cells diode current or saturation current differs with the cell temperature which is defined as:

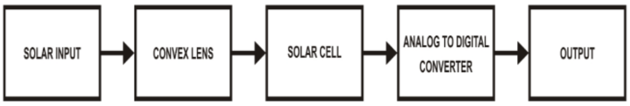

Fig. 3: Proposed solar system.

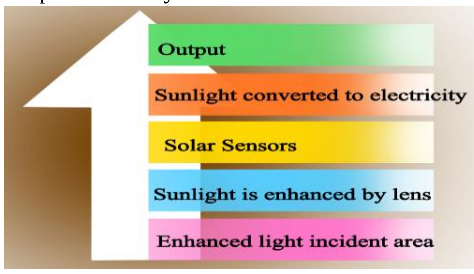

Fig. 4: The working principle of the modified solar system.

$$I_0 = I_{RS}\left(\frac{T_C}{T_{REF}}\right)^2 \exp\left[qE_G\left(\frac{1}{T_{REF}} - \frac{1}{T_C}\right)\Big/kA\right] \quad (6)$$

where I_{RS} is the cells reveres saturation current at reference temperature and with effective solar radiation and E_G is the band-gap energy of the semiconductor applied in cell.

IV. PROPOSED METHODOLOGY

It displays that after the use of Fresnel lens in the panel the output is increased significantly. The lens is used in such a manner that it concentrates the rays to a particular zone, which is shown with the proposed solar system in Fig. 3 and with the working principle of the modified solar system in Fig. 4. The hardware models with lens a without lends which is proposed in this work as an experimental purpose is shown in Figs. 5 and 6, consecutively. This preparation makes use of lens on upper walls and the bottom walls of the solar plate which behaves as an insulator would not permit the heat to flow out. In order to start the procedure, both the donor and acceptor must be able to absorb maximum photons in short time.

The solar chasing system like LDR i.e. Light Dependent Resistor is cast-off here for tracking the sunlight. It performs on the principle that its resistance goes down as the intensity of light increases gradually.

Table 1: Comparison between Conventional and Improved Solar Panel.

Conventional solar panel	Improved solar panel
Created less output	Created more output
Less Efficient	More Efficient
Size is large	Size is reasonably small
Costly	Price reasonable
Less intensity	More intensity
Less power	More Power


Fig. 5: The hardware set up with lens for PV.

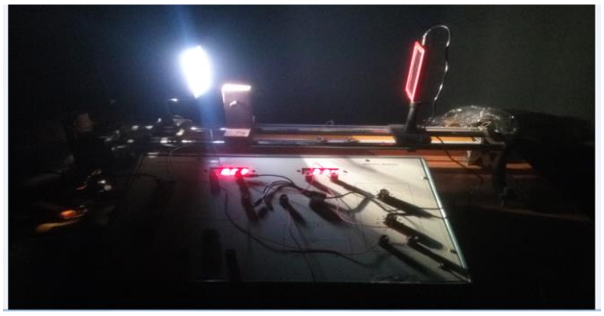

Fig. 6: The hardware set up without lens for PV.

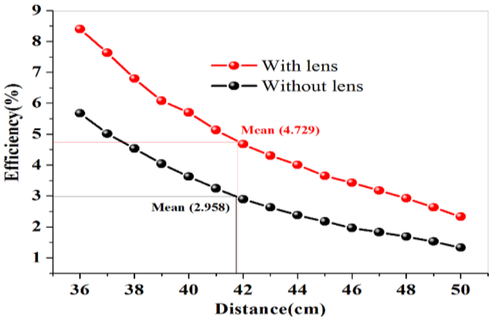

Fig. 7: Comparative analysis of Efficiency vs. Distance.

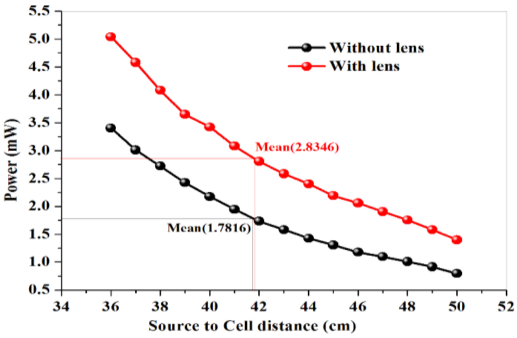

Fig. 8: Comparative analysis of Power vs. Source to cell distance.

Thus the circuit follows the movement of sun and adjusts it consequently so as to absorb maximum photons in those areas. Thus the anticipated output is achieved. The output can either be useful to run the devices or can be stored for later use (Chen *et al.*, 2013).

V. RESULT AND DISCUSSION

The comparative analysis between efficiency and distance, it has been noticed that as the source to cell distance is gradually being closer the efficiency of the soar PV is increasing much more vertically compared to the solar PV without lens, which is shown in Fig. 7. From the experiment it is also noticed that the efficiency is increasing almost 3% more with lens at a distance of 36cm. from source to cell. The corresponding mean value also clearly signifies that the higher efficiency is achieved with the use of Fresnel lens.

Doing comparative analysis between Power and source to cell distance, it has been observed that as the source to cell distance is progressively being closer the power of the solar PV with lens is increasing much more steep way compared to the solar PV without lens, which is depicted in Fig. 8. From the experiment it is also noticed that the power is increasing almost 2mW

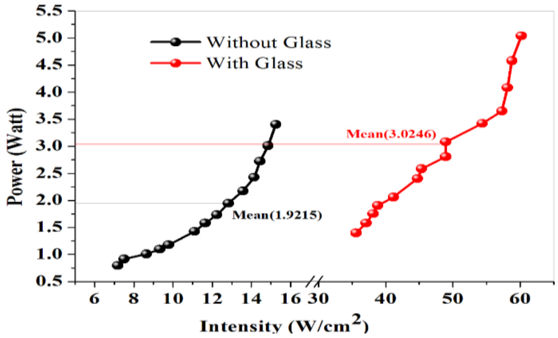

Fig. 9: Comparative analysis of Power vs. Intensity.

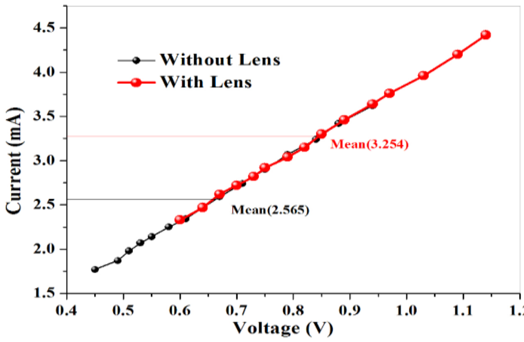

Fig. 10: Comparative analysis of Current vs. Voltage without varying the resistance.

more with lens at a distance of 36cm. from source to cell. The comparative study of the corresponding mean value from the graphs also clearly showed the same thing.

Performing the proportional analysis between Power and intensity, it has been verified that as the source to cell distance is progressively being closer, gradually intensity of the PV is becomes higher for both case but the power of the soar PV with lens is increasing much more sharp way compared to the solar PV without lens as the intensity is increasing, which is given in Fig. 9. The equivalent mean values shows the difference of power and it is clearly indicates that the power is higher with the use of lens compared to the power without the use of the Fresnel lens.

Executing the relative analysis between current and voltage without varying the resistance of solar panel, only the distance changing for both of the cases, it has been verified that the current vs. voltage characteristic follows the ohms law and as the source to cell distance is gradually being closer, current of the PV is becomes higher for both cases but the current of the solar PV with lens is increasing much more fast way compared to the solar PV without lens and the voltage and current value that has been observed is comparatively higher values with lens than the value without lens, which is demonstrated in Fig. 10. The analogous mean values also verify the same thing more prominently in the graphs.

Accomplishing the comparative analysis between temperature and source to cell distance, it has been noticed that as the source to cell distance is progressively being closer the intensity of the solar PV is increasing gradually for the cases but the temperature of the solar

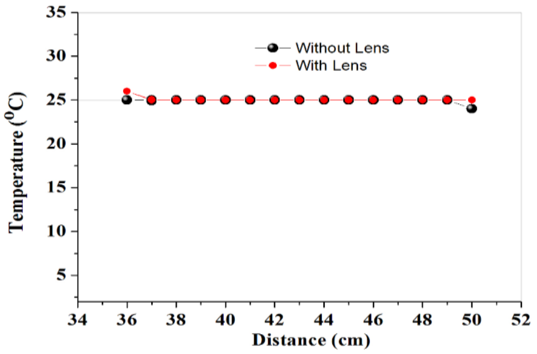

Fig. 11: Comparative analysis of Temperature vs. Distance.

PV with lens is not increasing so high compared to the solar PV without lens, which is observed in Fig. 11. From the experiment it has been seen that the temperature is almost fixed at around 25°C though the source to cell distance is getting closer and closer. So, it will be highly beneficial for the use of this modified solar PV in long run purpose.

VI. BENEFITS TO THE SOCIETY

Modified solar system with lens is useful to the people who are living in spacecraft, mountain areas, dense forest areas, northern points, southern points of the earth, desert areas where the sun light goes down quickly, in those areas this modified solar system is useful because it will help the solar panel to charge much more faster way and in quick time. Modified solar panel is environment responsive and does not create any pollution and is also a silent source of energy in every aspect. It is enormously consistent. This will help to decrease the dependability on fossil fuel based energy and enhance the standard of living in a broader way (Reis *et al.*, 2015).

VII. CONCLUSION

This study shows the modified design and mechanism with an effective experimental model to improve the power and efficiency of solar photovoltaic through a revised Fresnel lens process. Utilization of Fresnel lens in front of the solar photovoltaic certainly improves the efficiency, current and other parameters comparatively better than the conventional solar panel. From the result of the experiment, it is visible that with the help of a fresnel lens as the distance increases the power and efficiency are increasing comparatively better than without the lens and as intensity is increasing the power is also increasing relatively better than without lens format. The recent advanced technology which has been presented here proves that the use of Fresnel's lens before the solar photovoltaic plate enhances its energy comparatively better and it's a promising alternative to conventional huge concentrator method. The approach of the optical system has been boosted here for practical manufacturability and system application. This reformed combination can be useful for increasing the solar energy conservation in less time. Experiments have shown that the cell will perform at a reasonable temperature in terms of better efficiency, presentation and reliability with an admirable satisfaction in long run.

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