A Novel Architecture to Improve Performance of Photovoltaic Cells using Lens Let Arrays

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***Abstract*—The Green revolution as ushered in by the photovoltaic cells is all pervasive. Power production through photovoltaic cells is gaining momentum as it reduces the Green House Effect. But the photovoltaic cells are plagued by severe efficiency deficiencies. It is at only 40% to 50%. In this novel approach the author proposes a new technique of using lens let arrays in combination with a resonance cavity to improve the efficiency of the photovoltaic cells. The lens in a lens let array brings the Sun's radiation in the form of light energy to a focus on the photovoltaic cell. Since this increases the Intensity of the radiation at the PV cell surface the effective conversion rate of Photon to Electron increases. Consequently the output current increases thereby improving the performance of the photovoltaic cell.**

Keywords— Optics, Photovoltaic Cells

I. Introduction

Photovoltaic cells also referred to as 'PV' cells, harnesses the solar energy in order to produce electrical energy. The optical light energy from the sun is used to generate the required electrical energy by means of the photon – electron conversion process. The photovoltaic cell is basically a light sensitive device in which the photons falling on them produces electrons. These electrons are harvested by external circuits to create the flow of electric current, which can be stored in the form of energy to create the required DC (Direct Current) power. In combination with an inverter (DC to AC Converter) it can supply power for domestic and industrial consumptions. Thus the power generation of photo voltaic cell operation has zero green house effect.

The photovoltaic cell operates at an efficiency of 40% to 50% which implies that 50% to 60% of the light energy is not harvested successfully. In this project it is our objective to improve the performance of the Photovoltaic cell operation by using Lens Let Arrays (and Resonator combination) and hence improve the efficiency. Photovoltaic Cells are being deployed in large numbers in order to harness the Solar Energy. Photovoltaic cells operate only at an efficiency of 40% to 50% at their best. This implies that large amount of Solar Energy reaching the Earth surface is being wasted. In this project our objective is to improve the performance efficiency of PV cells to 90% and above. Some of the draw backs of the current systems are (1) Cost of Power Production using Photovoltaic Cells is high, (2) Efficiency of Operation is only between 40% to 50% and (3) Inefficient use of Photovoltaic Cell Active materials.

II. RESEARCH CHRONOLOGY

The project envisions to improve the efficiency of Photovoltaic Cells from 40-50% to 90%. This efficiency improvement will reduce the cost of electrical energy production by about 50% since the efficiency doubles. Internationally research and development in this area of efficiency improvement of Photovoltaic cells is progressing in the direction of Photosensitive material advancement. There seem to be NO efforts to introduce optical architectures in order to improve and increase the efficiency of Photovoltaic Cells. In this project our objective is to demonstrate the viability of an advanced optical architecture to improve the efficiency of Photovoltaic Cells. Nationally the deployment of Photovoltaic Cells is gaining tremendous momentum in order to produce electrical power using alternative energy resources, thereby reducing the Green House effect. There seem to be no research work undertaken similar to the proposed system in our country. This project gains significant importance as it will tremendously influence the Photovoltaic Cell deployment in the country. The most important factor will be that because of efficiency improvement the cost of production of power will come down significantly, resulting in improved usage of photovoltaic cells by the public. It is becoming a viable alternative for power production when compared to conventional schemes like thermal and nuclear power production schemes.

III. Architecture Of The Proposed System

In this proposed architecture the photovoltaic cell is placed inside a resonant cavity. The biconvex lens is placed above the photovoltaic cell and facing the Sun's radiation. The Sun's radiation as a parallel rays of optical wave fronts reaches and falls on the lens placed over the photovoltaic cell. The parallel beams of light energy is brought to a focus on the surface of the photovoltaic cell. This process ensures that the density of the photons on the surface of the photovoltaic cell is much higher than the density of photons on the rear side of the lens. This increase in Intensity of light enhances the photon electron conversion as this process is directly proportional of the Intensity of the falling sunlight. The conversion probability is higher in this architecture and hence the efficiency is higher. Those photons that does not get converted itself as electrons are trapped by the resonator architecture. These trapped photons will once again interact with the photovoltaic cell. This further enhances the conversion process and further improves the efficiency.

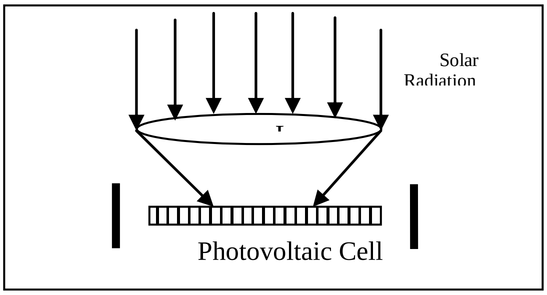

Fig. 1. The Proposed Architecture.

The electromagnetic energy containing all constituent optical frequencies is represented as

$$U(r,t) = 2\int_0^\infty U_v(r)\, exp(j2\pi vt)dt$$

The Intensity of the composite optical radiation is given by

$$I(r,t) = |U(r,t)|^2$$

The mean photon flux density is

$$\emptyset(r) = \frac{I(r)}{hv}$$

The mean photon flux is given by

$$\emptyset = \int_A \emptyset(r)\, dA = \frac{P}{hv}$$

The mean photon number at the surface of the photovoltaic cell is as

$$\bar{n} = \emptyset T = \frac{E}{hv}$$

From the above equation it is clear that the mean number of photons at the surface of the photovoltaic cell is directly proportional to the Intensity of the light falling on its surface. This higher photon availability increases the interaction between these photons and the electrons. Thereby increasing the conversion rate from the photon to the electron; This results in increased current flow out of the photovoltaic cell which can be stored and harnessed for usage at a later point of time.

IV. CONCLUSION

The photon electron conversion process is enhanced to a very high level as the conversion process is proportional to the photon availability (because of higher intensity). The lens let array system enhances the photon-electron interaction by making the photovoltaic conversion process more efficient. By this method a higher percentage of photons get converted to electrons resulting in higher current and hence increasing the efficiency of the photovoltaic system.

REFERENCES

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