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Experimental Measurements of a Prototype High-Concentration Fresnel Lens and Sun Tracking Method for Photovoltaic Panel's Efficiency Enhancement

M. Rajaee
The Technical and Vocational University of Tehran,, Iran, ,e-mail: m.ragaee@tvu.ac.ir

Photovoltaic Concentrator modules are a promising technology for high efficiency solar energy conversion. This system presents several advantages due to additional degrees of freedom that has been provided by the spectral separation such as cost and mass reduction, increase in the incident solar flux in PV cells and performances.

This paper has proposed a unique photovoltaic solar cell system that consists of semi-Fresnel lens convergent structure and a novel to axis sun tracking module to enhance the efficiency of solar cell by using less cell area and energy losses.

The grooves of this lens are calculated according to the refraction and convergent angles of the light easy for perpendicular incidence angle. The lens is flat on one side and has fine grooves on the other side. Our purpose is to concentrate all incoming rays to the central line in the focus of the lens. Although some researchers have tried to use TIR to reduce the spherical aberration and reduce the focus area, we prefer to eliminate TIR by designing the groove angles based on the convergent angle a so that all the incoming rays can be refracted directly to the focus point. We drove the angle of grooves based on Snell's law and trigonometry. As a result energy loss due

to both spherical aberration and TIR is eliminated.

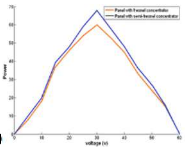
Figure 1. The whole structure for testing the performance of the proposed structure.

The update time interval during tracking causes misalignment of the lens' optical axis versus the sunrays. Then an inventive sun-tracking method is introduced to adjust the module so that the incident rays are always perpendicular to the module's surface. We proposed a two-axis automatic sun-tracking system driven by motor with angle sensor feedback. The driving system was open loop with controller to reduce errors of the angle output. As a result, all rays will be refracted with the predetermined angles. This way the focus are is reduced and smaller cells can be used. Our proposed two-axis sun-tracking algorithm works based on calculations of the incidence angle according to date, time, and geographical position of panel (which means latitude, longitude, and zenith.)

We also mentioned different module connection in order to provide compensation method during losses, for networks and power systems.

Experimental results show that using semi-Fresnel lens, along with the sun-tracking method increase the efficiency of PV panel.

(a)



(b)

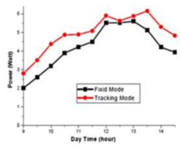


Figure 2. a Power versus voltage for the panel with Fresnel concentrator (red line) and semi-Fresnel concentrator (blue line) **b** Output power of PV system with and without sun tracking