Novel Linear Fresnel Lens-Based Primary Optical Element for Concentrator Photovoltaic System

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Abstract

In this paper, we present a design and optical simulation of a novel linear Fresnel lens. The lens is applied to the concentrator photovoltaic (CPV) system as a primary optical element (POE) to increase the concentration ratio and improve the uniformity of irradiance distribution over the receiver. In addition, the CPV system can use the proposed lens as a concentrator without involving secondary optical element (SOE). The designed lens, which is a combination of two linear Fresnel lenses placed perpendicular to each other, can collect and distribute the direct sunlight on two dimensions instead of one dimension if we use the conventional linear Fresnel lens. The lens is first designed in Matlab program based on the edge ray theorem, the Snell's law, and the conservation of optical path length and then drawn in three dimensions (3D) by using Lighttools™. Furthermore, in order to optimize the structure and investigate the performance of the lens, the ray tracing and the simulation are also performed in Lighttools™. The results show that the newly designed lens can achieve high concentration ratio of 576 times, high optical efficiency of 82.4%, acceptable tolerance of 0.8^0, and high uniform irradiance of around 77% for both horizontal and vertical investigation lines over the receiver.

Images

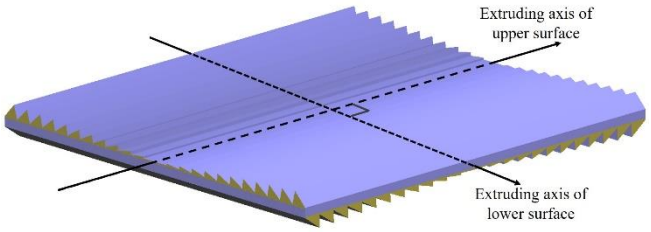

Figure 1. The novel linear Fresnel lens in 3D with the grooves surfaces perpendicular to each other.

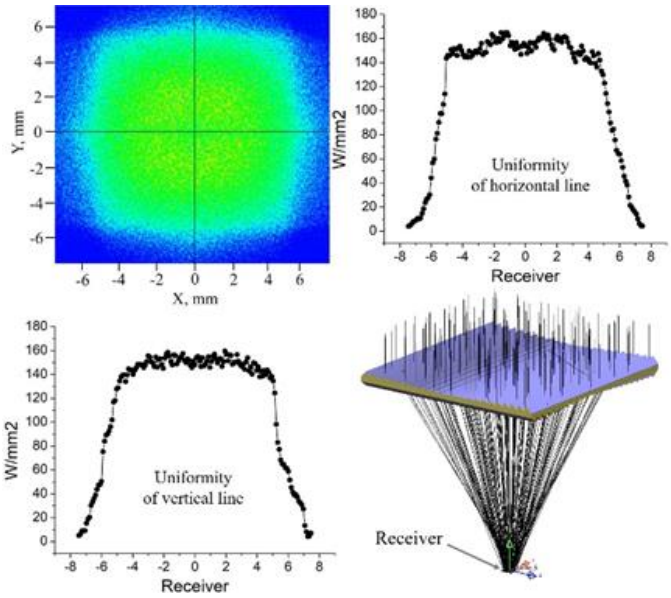

Figure 2. The ray tracing of the lens and the irradiance distribution of the sunlight over the solar cell.

Acknowledgement

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Recent Publications

1. Pham Thanh Tuan, Vu Ngoc Hai, Seoyong Shin (2018) Design of Curved Fresnel Lens with High Performance Creating Competitive Price Concentrator Photovoltaic. Energy Procedia, doi.org/10.1016/j.egypro.2018.06.004
2. Vu NH, Shin S (2017) Flat Optical Fiber Daylighting System with Lateral Displacement Sun-Tracking Mechanism for Indoor Lighting. Energies doi:10.3390/en10101679
3. Vu NH, Shin S (2017) Flat Concentrator Photovoltaic System with Lateral Displacement Tracking for Residential Rooftops. Energies doi.org/10.3390/en11010114
4. Pham TT, Vu NH, Shin S (2017) Daylighting System Based on Novel Design of Linear Fresnel lens. Buildings doi.org/10.3390/buildings7040092
5. Vu NH, Pham TT, Shin S (2016) Modified optical fiber daylighting system with sunlight transportation in free space. Optics Express doi.org/10.1364/OE.24.0A1528

Biography

Professor Seoyong Shin has been in the Department of Information and Communication Engineering at Myongji University since 1994. He has published more than 50 SCI and SCI-E papers so far. He started research in the field of optical communication, especially optical active functional modules including wavelength converter, optical buffers for WDM network, and dynamically gain-controlled EDFA for WDM networks. His research has moved on to solar energy related topics since 2007 where he can apply his prepared knowledge of optics and optical fibers. His main interested topics are optical fiber-based daylighting system and concentrator photovoltaic systems.

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