Optimization of LED-based Optical Wireless Power Transmission for Compact IoT

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1. Introduction

Power supplying for IoT terminals such as sensors, beacons, and tags, is always an issue. Wiring or exchanging the battery needs excessive costs. Optical wireless power transmission (OWPT) has advantages such as a high degree of freedom, which is promising as an optimal choice.

In this paper, improvement of the previous report[1)] on the system dimension and performance of the LED-based OWPT systems is shown in detail, and an optimized system configuration for compressing the module dimension is proposed.

2. Configuration of IoT-OWPT

The OWPT system for compact IoT basically consists of a portable power transmitter (light source) with a beam control system (lens system) and a power receiver on an IoT terminal (solar cell). For high photovoltaic conversion efficiency, a GaAs solar cell with a size of 1.7x1.7 cm^2 and an infrared (IR) LED (±20°) with a wavelength of 810 nm were prepared in this study. The multi-lens system shown in Fig. 1 consists of an aspheric condenser lens and a Fresnel lens. An aspheric condenser lens with a diameter of 32.5 mm and a focus length of 23.5 mm was selected, whose angular magnification is almost the smallest in market. The light weight of the Fresnel lens is suitable for OWPT systems. Based on Newton's formula, the transversal magnification is inversely proportional to the distance between the two lenses, which is L value in Fig. 1. According to the numerical simulation, the relation between L value, aperture size, and side length of irradiation size at a transmission distance of 1 m is shown in Fig. 2. The aperture size is selected to collect more than 90% of the intensity from the IR LED. As the result, larger size of the OWPT system can achieve a smaller irradiation size, thus it is important to consider a configuration that reduces the system size if a smaller irradiation size is required.

3. Configuration optimization

In order to reduce system size, a configuration using mirrors to maximize space utilization is proposed in Fig. 3. It is important that the L value ensures the correct conjugate distance. Systems with an L value smaller than 100 mm can maximize space compression by inserting a single mirror with a 30° tilt angle between the two lenses. When the L value is larger than 100 mm, a two mirror configuration is proposed for ensuring proper conjugate distance while reducing the system dimension. This configuration can compress approximately 30% of horizontal distance compared to the original configuration.

4. Conclusion

An improvement in the design of an LED-based OWPT system was reported in this paper. The characteristics of the system dimension and irradiation performance were reported. Besides, for reducing system dimension and achieving good irradiation, optimized system configurations have been proposed.

References

1) Y. Zhou, Y. Ishida and T. Miyamoto, JSAP2019spring, 11p-W611-1.

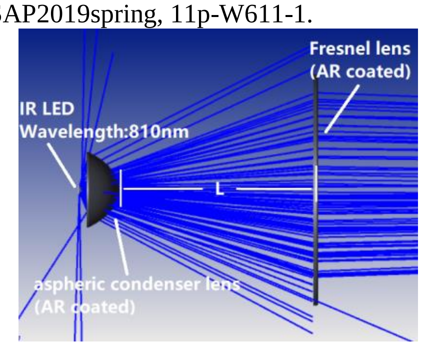

Fig. 1. Configuration of lens system

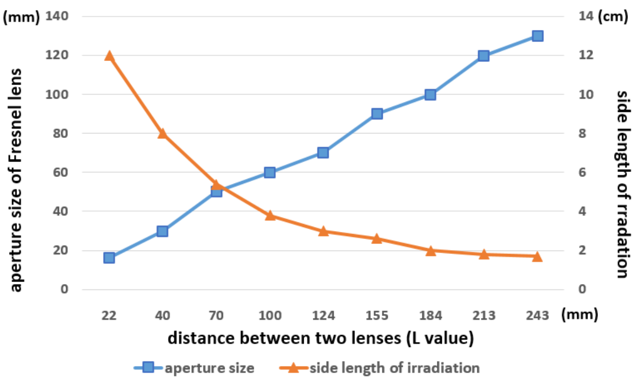

Fig. 2. Relation of system dimension and irradiation

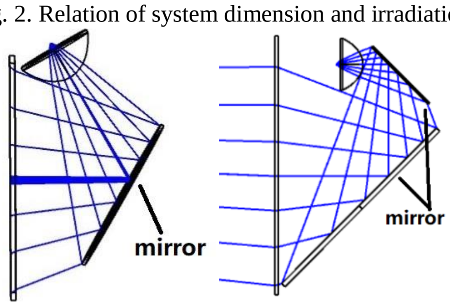

Fig. 3. Reflection optical system configuration