Designing of LED-array Optical Wireless Power Transmission System

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1. Introduction

Due to the factors such as relatively loose regulation and better tolerance to heat compared with laser, LED-based optical wireless power transmission (OWPT) system is a potential candidate for remotely power charging application. However, the output power of OWPT system with single LED is difficult to raise due to current manufacturing technology. Thus, investigating on LED-array OWPT system is far more necessary. [1)] In this paper, two kinds of LED-array OWPT system and simulation results are investigated as advanced design of previous report shown in Ref. 1).

2. Designing of LED-array OWPT system

In this research, two kinds of 4-LED arraying methods and irradiance map shown in Fig. 1 are investigated. For single-lens array configuration (Fig. 1, left), condenser lenses (50 mm diameter, 38 mm focal length) are applied to each LED as collimation lens, and a single Fresnel lens with 120 mm aperture and 1 m focal length is selected as image lens for focusing. The irradiation size is 3.2 cm × 3.4 cm and overlapped. Longer focal length of collimation lens will rapidly decrease the irradiation size and increase irradiance, then enhance conversion efficiency of solar cell. On the other hand, due to LED is located at back focus point of lens in order to achieve collimation, large value of focal length will cause light source far away from lens, then lead out great geometrical loss. Thus, efficiency of single-lens configuration is usually around 60%. In order to enhance system efficiency, double-lens LED-array configuration is proposed in the Ref. 1. Collimation of such configuration will be finished by two condenser lenses, and light source can be closely placed near the first lens rear surface, thus geometrical loss is largely decreased compared to first configuration. The efficiency of such system is enhanced to 90%. On the opposite side, due to one more lens is applied, the irradiation size is increased.

3. Simulation results

Figure 2 compared the simulation results of two different configurations of 4-LEDs array OWPT system and single LED OWPT system with 1 m transmission distance. For single-condenser lens configuration, due to the smaller irradiation size, the saturation point can be quicker to reach with size of solar cell increasing. On the other side, double-lens configuration has higher efficiency, thus after reaching the critical size of the solar cell, the double-lens configuration can convey more intensity at the receiver. For 4 LEDs single-lens configuration, the output power will be around 1W if 40% PV conversion efficiency is assumed, and 1.5W for double-lens system. And considering the expected higher PV conversion efficiency of the solar cell due to higher radiant intensity, actual output power from LED-array system will be more than prediction. Generally, single-lens system has simple design, smaller irradiation and higher irradiance compared with double-lens system, while on the other side, its efficiency will be lower due to geometrical loss.

4. Conclusion

The design of LED-array OWPT system for high output power was reported. The experiment on LED-array OWPT system is undergoing, and the experiment data will be reported at presentation.

References

1) Y. Zhou and T. Miyamoto, JSAP2020spring, 15p-B410-9.

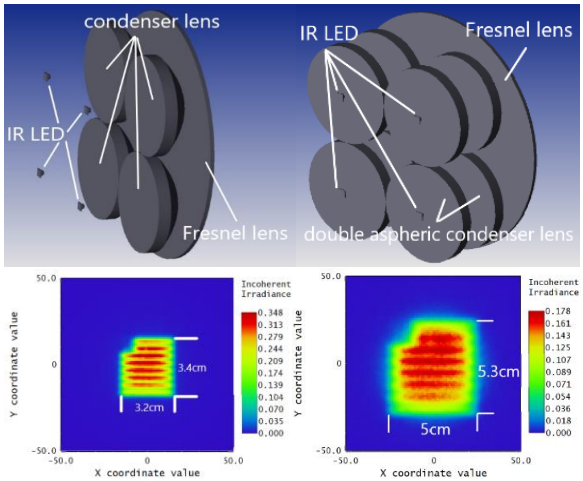

Fig. 1. Model of LED-array system and irradiance map

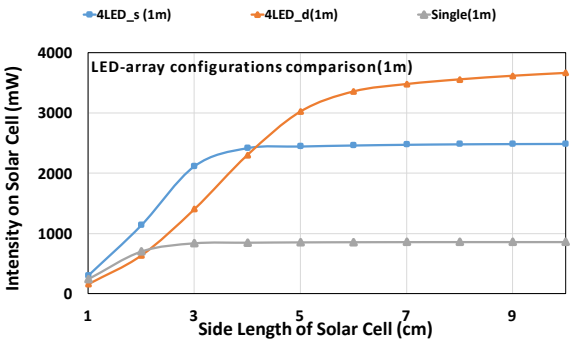

Fig. 2. Simulation results of 1 m power transmission