Integrated module of LED array based optical wireless power transmission system

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1. Introduction

In recent years, LED-based optical wireless power transmission (OWPT) system has been a feasible candidate for powering remote applications, especially IoT terminals. 1 W electrical output has been achieved by a 3×3 LED array OWPT system.[1)] However, this system suffered the low transmission efficiency. And there is no demonstration of a high-performance power source module at current stage.

In this research, a high-efficiency LED-array system will be designed. And the experiment will be applied according to the optimal simulation. Finally, the power source module will be integrated as a small-size and lightweight device.

2. Lens system design and experiment

Due to the large divergence of LED, an additional lens system is necessary. A high-performance LED with ±60° divergence angle is selected as the light source in our research. In order to increase the irradiation power on a small irradiation spot area, LED-array forms the power source and the lens system design follows the principle of collimation scheme.[2)] LEDs are placed at the front focal points of corresponding collimation lenses. Then an imaging lens focused the collimation beam on 1 m away receiver. Therefore, the irradiation spot from each LED is overlapped as one area.

In this collimation scheme, the *f-number* of collimation lens is the essential factor affected the lens system efficiency. *f-number* is defined as the focal length divided by effective aperture diameter. In the collimation scheme, *f-number* = 0.5 collimation lens can minimize the power leakage from LED divergence and cause optimal irradiation performance.

Therefore, at this time, novel lens systems are designed to improve the transmission efficiency in LED-array based OWPT. The LEDs (OSRAM SFH4715AS, 1.53 W, 1×1 mm^2, 850 nm), imaging lens (*f*=1000m, 100×100 mm^2) and solar cell (GaAs, 50×50 mm^2) are the same as our former research.[1)] The *f-number* = 0.5 lenses (*f*=25 mm, *d*=50 mm) form the collimation lenses. 2×2 array LEDs are arranged in a square shape with 50 mm side length. Fig. 1 (left) shows the simulation design by Zemax software.

The experiment setup follows the simulation design, as shown in Fig. 1 (right). Four LEDs are in series connection and fixed on a 100×100×20 mm^3 Aluminum heat sink. Due to the advantages of lightweight and small *f-number*, all lenses are selected as Fresnel lenses.

As for the results, in the simulation, the lens system efficiency is as high as 72.06%, which is 1.8 times larger than the former 1 W electrical output system.[1)] In the experiment, the irradiation spot area at 1 m is 68×77 mm^2. From the 50×50 mm^2 area GaAs solar cell at 1 m, the maximum electrical power is 0.795 W.

3. Integrated power source module

The power source module consisting of a heatsink, LEDs and lenses, is also integrated as a portable device, shown in Fig. 2 (left). The box frame is fabricated by a stereolithography 3D printer (Flashforge Foto 8.9s). This integrated device has relatively small dimension and lightweight. Fig. 2 (right) shows that the total dimension is 120×114×61 mm^3. The weight of the integrated power source device is 407.1g. Due to the compact size and lightweight features, this power source can be carried by humans or robots for a temporary power supply.

4. Conclusion

In the novel designed 2×2 LED-array OWPT system, 0.8 W electricity output has been achieved from a 50×50 mm^2 receiver at 1 m. The lens system efficiency has been improved from 40%[1)] to 72%. The power source module can be integrated as a compact and portable device.

Reference

1) M. Zhao and T. Miyamoto, "1 W High Performance LED-Array Based Optical Wireless Power Transmission System for IoT Terminals," MDPI-Photonics, 2022; 9(8):576.

2) Y. Zhou and T. Miyamoto, "400 mW Class High Output Power from LED-Array OWPT System for Compact IoT," IEICE Electronics Express 2021, 18 (2).

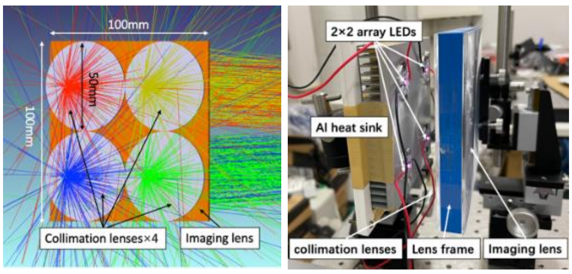

Fig. 1. System design (left) and experiment setup (right)

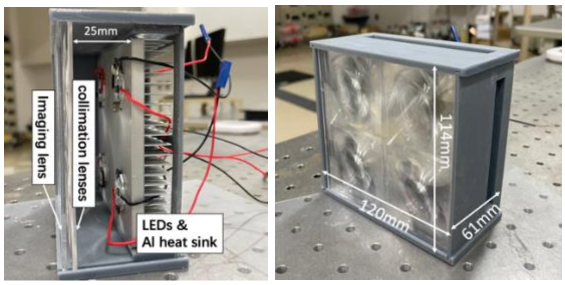

Fig. 2. Integrated module (left) and dimension (right)