Numerical design for size reduction in light source module of LED-OWPT system

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1. Introduction

Optical wireless power transmission (OWPT) technique is rapidly developing because OWPT offers advanced features for long distance transmission and no EMI[1). Considering the laser safety restriction and cost-effective configuration, near infrared LEDs have been selected as the light source for charging IoT small terminals in this study. At the current stage, a single chip LED based OWPT system has been demonstrated with 200 mW class electrical output power at 1 m transmission distance using a 17×17 mm^2 GaAs solar cell[2). The length of the lens set of that system is 102 mm using a commercially available high numerical aperture (NA) convex lens. In this study, we designed an improved configuration of the LED-OWPT system based on two Fresnel lenses to reduce the length of the lens module.

2. Designing of two Fresnel lenses OWPT system

In order to shorten the size of portable OWPT device, a system based on two Fresnel lenses was designed. Compared to convex lenses, Fresnel lenses are extremely light and thin, which accepts the portable requirement appropriately. In addition, due to the feature of configurable of a higher NA, a large lens aperture can be applied at the same focal length. Considering a method of collimating the beams and then focusing, the length of the portable device is only depended on the first lens focal length. In the previous design, due to the limited NA of the convex lens (50 mmϕ, *f*=50.0 mm), the lens was set close to the LED. Therefore, collimated beam was not used and a relatively long distance between the convex lens and the focusing Fresnel lens was required to achieve a small irradiation pattern.

As shown in Fig. 1, the OWPT system is designed and optimized using ZEMAX by applying an IR LED (OSRAM SFH4715AS, 1680 mW, λ = 850 nm), a Fresnel lens 1 (100 mmϕ, *f*=50.0 mm), and a Fresnel lens 2 (100 mmϕ, *f*=948.7 mm). The distance between the two lenses is 5 mm. The divergent light rays are collimated by the first Fresnel lens, and then lens 2 focuses the collimated beam at a 1000 mm distance, where a 17×17 mm^2 GaAs solar cell is placed. By generating a collimated beam, the distance between the lenses is sufficiently short.

As shown in Table 1, comparing with the previous combination of convex lens and Fresnel lens[2), the length of the lens module is reduced from 102 mm to 55 mm. However, still due to the light leakage by the large divergence of the light source, the light irradiation power reduces from 352 mW to 273 mW at a 1000 mm position.

3. Conclusion

A LED-OWPT system based on two Fresnel lenses has been designed and the length of the lens module is reduced to 55 mm, which enables a portable system miniaturization and lightweight.

References

1) T. Miyamoto, "Optical wireless power transmission using VCSELs," Proc. SPIE 10682, (2018).
2) Y. Zhou and T. Miyamoto, "200 mW-class LED-based optical wireless power transmission for compact IoT," Jpn. J. Appl. Phys. 58, SJJC04 (2019).

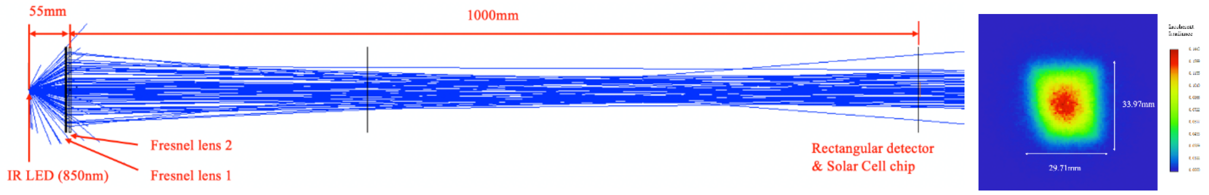

Fig. 1 Simulation of the OWPT system based on 2 Fresnel lenses and 1000 mm irradiance map

Table 1 Length, input power and spot size of different lens sets

	Length of lens set	1000 mm solar cell input power	1000 mm light spot size
1 Convex lens & 1 Fresnel lens	102 mm	351.8 mW	30.4 × 26.2 mm^2
2 Fresnel lenses	55 mm	273.1 mW	34.0 × 29.7 mm^2