Numerical analysis of power generation characteristics in beam direction control of indoor optical wireless power transmission using mirror

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1. Introduction

Optical wireless power transmission (OWPT) has characteristics of long-distance power transmission and no leakage of electromagnetic waves compared to existing wireless power transmission [1]. In an OWPT system with a simple light source, the energy transmission efficiency begins to decrease rapidly due to beam deformation when the horizontal distance of the solar cell module increases from the light source [2,3].

In this research, we proposed an OWPT system with mirrors to improve the energy transmission efficiency of the OWPT system under long distance and large inclination angle. For the required power generation characteristics, the variable divergence angle and the number of mirrors needed for different size of room was investigated.

2. Configuration of OWPT system with mirror

As an indoor OWPT system, a light source (laser) is installed to the ceiling, and a power receiving unit (solar cell) is placed on the floor. The ceiling height is 250 cm. The solar cell is parallel to the floor and the size is 10 cm square as a typical or acceptable configuration. As shown in Fig. 1, the rotatable mirror is placed 400 cm from the light source at the same height as the light source. Beam can be irradiated on the solar cell with a small inclination angle by mirror, thus avoiding energy waste caused by the beam irradiation outside the solar cell.

3. Analysis of proposed OWPT system

The power generation ratio of OWPT system with mirror was calculated by multiplying the power generation ratio of OWPT system by 95% of the reflectivity. Figure 2 shows the power generation ratio of the proposed system with a light source of 5 mm square and various divergence angles. The power generation ratio can be 0.7 or more in the range from 150 cm to 650 cm. By combination of a condition without mirror (<300 cm for 0.7), a power generation ratio of 0.7 or more can be achieved within distance of 650 cm, which leads to the extension of the high efficiency distance. In addition, relatively high efficiency over a wide area can be selected in two ways: direct irradiation by a laser or indirect irradiation by a mirror, which makes beam transmission more flexible, and allows energy to be transmitted even when the direct beam is blocked by obstacles.

Figure 3 shows the number of mirrors needed in a room under different required power generation ratios. The mirrors are placed at concentric circles. More mirrors are required for larger room or higher required power generation ratio.

4. Summary

We confirmed that using mirrors in OWPT system can effectively expand the range of application of the optical wireless power transmission in the room. However, the multiple modules with active mirrors are required, and the reflection loss is a disadvantage.

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References

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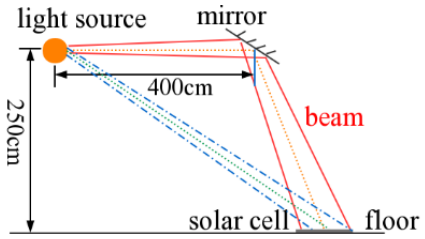

Fig. 1. Indoor light beam irradiation model using mirror.

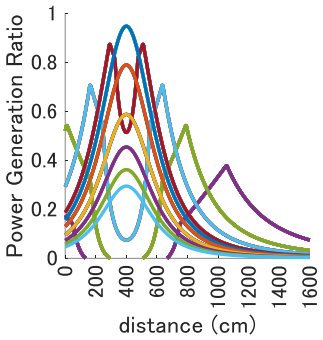

Fig. 2. Power generation ratio for 5 mm light source reflected by a mirror.

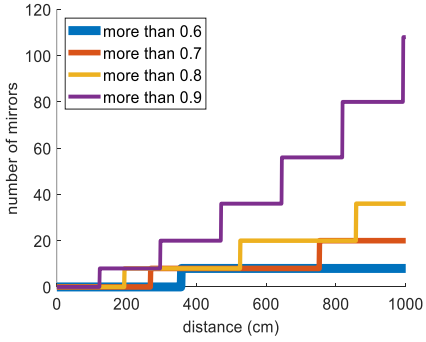

Fig. 3. Number of mirrors for various size of room.