Power confirmation method from radio wave using rectenna for SPS demonstration satellite.

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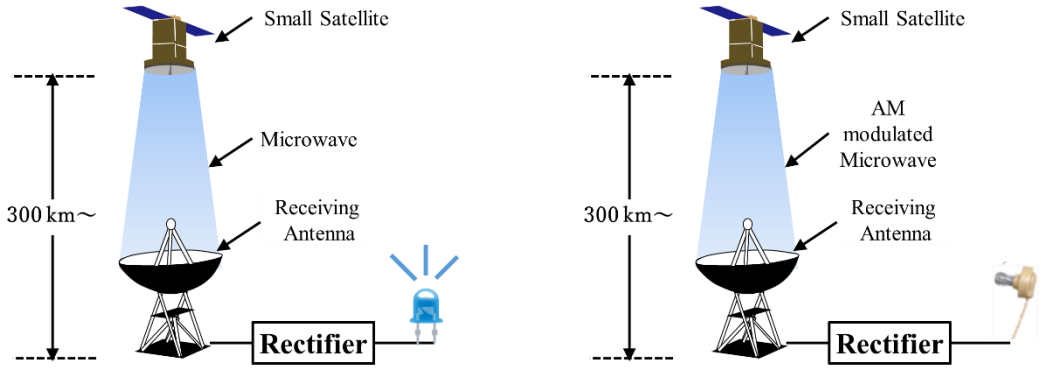
A satellite-to-ground space solar power demonstration test has been proposed to verify long-range beam control technology using small satellites [1]. Since the demonstration test will obtain radio signals from the satellite as electric power on the ground, if the satellite received power can be appealed to society in an easy-to-understand manner, it will promote understanding of space solar power technology. Two types of easy-to-understand confirmation methods will be considered: one using un-modulated waves and LEDs, as shown in Figure 1, and the other using AM modulated waves and earphone.

In the demonstration test, microwaves at a frequency of 5.729 GHz are radiated to antennas at a distance of 300 km or more. Therefore, we studied the receiving antenna and rectifier circuit required for the LED and earphone to work in the demonstration test, and conducted a simulated test in which unmodulated (CW) waves at 438.25 MHz and AM modulated waves at 1.5 kHz were radiated to an antenna at a distance of 20 m from the antenna.

As a result of the study, it was found that the diameter of the antenna required for the LED to operate is 21 m, while the earpiece is 2.1 m, or 1/10 the diameter of the antenna. In addition, the results of inputting 5.7GHz CW and AM waves modulated at 1.5 kHz to the rectifier circuit showed that AM waves have better rectification efficiency in the low power region. Simulated experiments yielded the results shown in Table 1, confirming that the earphones required 34.5 dB less power to operate than the LEDs.



(a) Rectenna with LED (b) Rectenna with earphone

Figure 1. Power Transmission Experiment from Space by Demonstration Test

Table 1. Power for LED or no-power radios to operate

	carrier wave Frequency [MHz]	Required Transmitting power [dBm]	Transmitting antenna gain [dBi]	Distance [m]	Free space loss [dB]	Receiving Antenna Gain [dBi]	**Operated Minimum Received Power** [dBm]	Difference in minimum received power [dB]
CW (LED)	438.25	44.5	9.3	20	54.29	5	4.51	0 (True Value:1)
AM (1.5kHz)	438.25	10.0	9.3	20	54.29	5	-29.9	34.5

References

[1] K. Hashimoto, T. Mitani, J. Yoshino, M. Yajima, D. Joudoi, H. Ikeda, et. al, "Microwave Beam Control Experiment Using Small Scientific Satellites for Solar Powered Satellites II," *14th Space Science Symposium*, April 2014, pp. 2-185.