Efficiency measurement of a 5.8 GHz Microwave Wireless Power Transmission System

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Space solar power station (SSPS) which is a huge solar satellite system in geosynchronous orbit, will be one of the future energy sources. The SSPS transfers the power to the earth and its key technology is microwave power transmission. This paper introduces a 5.8 GHz microwave power transmission system. In 1975, W.C Brown developed a 2.45 GHz microwave power transmission system. The transmission efficiency (DC-DC) of the system achieved 54 ± 1% at 2 meters distance [1] which is the highest transmission efficiency in the world even now. $\eta_{MW\ generation}$, $\eta_{transmission}$, $\eta_{rectification}$ was 69%, 95% and 82% , respectively [1]. The DC-DC efficiency can be described as Eq. (1), $\eta_{MW\ generation}$ is the efficiency of the microwave power generation, $\eta_{transmission}$ is the antenna transmission and received efficiency, $\eta_{rectification}$ is the efficiency of the microwave rectifier.

$$\eta_{DC-DC} = \eta_{MW\ generation} \times \eta_{transmission} \times \eta_{rectification}. \quad (1)$$

In this study, we build a 5.8 GHz microwave wireless power transmission system as shown in Fig.1. The microwave was generated by a 5.8 GHz magnetron (Panasonic M5801J, 5.784 GHz). The microwave feed into a 1-to-32 waveguide-to-coaxial radial divider. Each element of the patch antenna array connected to a divider output port independently via a coaxial cable. At 5.6 meters in front of the antennas, the receiver is a 5.8 GHz rectenna array system (IHI, 2014) which is constructed by 2304 pieces rectenna. The DC power input of this wireless power transmitter was 1125 W when the anode current and voltage of the magnetron was 250 mA and 4500 V. The magnetron generated 724 W microwave, whose efficiency was 60.7%. The rectenna array system outputted a DC power of 109.4 W through rectification. The DC-DC efficiency of this wireless power transmission system was 9.73%. The highest efficiency of the rectenna array system was 50% when the received power of each rectenna maintained at a scope of 200mW~800mW. Here, not all of the rectenna worked at the optimal condition. Despite there are no precise data to show $\eta_{transmission}$ and $\eta_{rectification}$, the value of $\eta_{transmission} \times \eta_{rectification}$ could be calculated as 30.2%. However, the divider and the coaxial cables of the transmitter consumed almost 50% microwave power. The $|S_{21}|$ parameter between waveguide port and each antenna port was -18 dB.

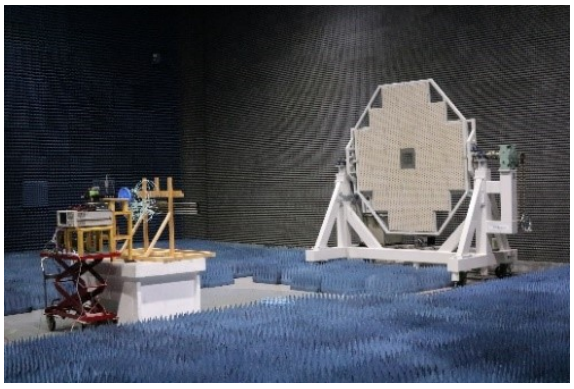

Figure 1. 5.8 GHz microwave wireless power transmission system. (9.73% DC-DC efficiency at 5.6 m distance)

The transmission efficiency and the power loss part of this system are precisely measured. In the next step, we will focus on the DC-DC efficiency enhancement of the microwave wireless power transmission system.

References

[1] Brown. W. C," Free-space microwave power transmission study, phase 3", NASA-CR-144151, PT-4601, September 10, 1975