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SPACE POWER SYMPOSIUM (C3)
Wireless Power Transmission Technologies, Experiments and Demonstrations (2)

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MICROWAVE POWER TRANSMISSION DEMONSTRATION SYSTEM TOWARDS SSPS

Abstract

This paper presents a MPT (Microwave Power Transmission) demonstration system comprehensively simulating the operating mode of MPT in SPS in several ways: the system scale minification, beam scan range, transmitting antenna field distribution, power density at rectenna and retrodirecitive beam control method. The diameters of transmitting antenna and rectenna are about 1.1 m and 4.3 m respectively, correspondingly the transmission distance is about 36 m. The transmitting antenna beam scan range is 0-8.5 degrees, and the aperture filed distribution is approximately Gaussian distribution. In order to achieve 23 mW/(cm*cm) power density at the center of rectenna, the transmitting microwave power must be about 900 W. The transmitting antenna array is a planar microstrip antenna array approximately circularly shaped consists of 148 sub-arrays. The transmitting powers of sub-arrays are divided into 7 levels in order to form a quasi-Gaussian distribution. Each sub-array is 2x2 circular polarized elements microstrip antenna array operating at 5.8 GHz. The distance between the centers of each sub-array is about 0.77 λ (8 cm). The FNBW (Fist Null Beam Width) is 9 degrees and the highest side lobe is about -26 dB. The rectenna is based on the concept of artificial perfectly matched layer. By embedding rectifying diodes into well-designed metamaterial cells, the obtained rectenna simultaneously exhibits a nearly perfect impedance matching to the air and the rectifying circuits, and a strong impedance mismatching to the air at harmonic frequencies, leading to a simple structure that can be implemented using commercial multi-layer printed circuit board technology. The beam control method is based on DOA estimation by sending pilot signal from rectenna site and beam synthesis by controlling the phase shifters in the transmitting antenna array. The system attempts to validate the functions and efficiency of MPT technologies towards SSPS in the following aspects: the constraint relationship between the sizes of transmitting antenna and rectenna and the transmission distance and its effect on transmission efficiency; the field distribution of transmitting antenna array and its effect on transmission efficiency; the fluctuation of power density at rectenna and its effect on transmission efficiency; the accuracy of beam control and its effect on transmission efficiency.