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DEVELOPMENT OF AN ARRAYED RECTENNA SYSTEM TO DEMONSTRATE 1.8KM WIRELESS POWER TRANSMISSION FROM A DEEP SPACE ANTENNA TO AN AEROSTAT

Abstract

An arrayed rectenna system was developed to receive energy wirelessly at a distance of over 1km when the Korea Deep Space Antenna (KDSA), with a diameter of 35m, transmits several kW of microwaves. An LHCP patch antenna operating at 2.08GHz was designed since the KDSA uses the frequency for Korean lunar orbiter control and operation. A rectifying circuit with a voltage doubler structure of GaN-based diodes was also designed. It has a matching circuit that controls the center frequency and second harmonics to have a high RF-DC efficiency, measured by 66.1%. A single rectenna was fabricated by integrating a patch antenna and a rectifier in a four-layered board, and a sub-array rectenna with 3 x 3 elements was developed, including a combined DC output port. A single rectifier can handle microwaves of up to 4 W and output 2.64W of DC, and a sub-array rectenna of 30 x 30cm can provide 23.8W. A direct drive module was also developed that connected to a sub-array rectenna and lit up LEDs without any battery. The number and color of LEDs are designed to vary in eight levels depending on the supplied power. A power measurement module was manufactured to deliver the voltage and current values of the rectenna output from the aerial to the ground. It can provide the appropriate voltage level to the AD converter on the communication module installed in the aerostat. The arrayed rectenna system was manufactured, integrating nine sub-array rectennas and LED driving modules. The rectenna system also includes the measurement module and was installed on the aerostat's steering device. The system is 3.6kg, 90 x 90cm, and can supply more than 200W. A 2.3kW microwave was transmitted 1.81 km from KDSA to the aerostat to measure a rectified power of 125mW. Also, the LEDs were lit by another experiment transmitting 1.82km from KDSA to a ground-fixed rectenna system with a height of 55m. Despite preparing a GaN-based rectenna system that can accommodate high power, the experiments were conducted at a lower power level than expected due to limitations such as permission for KDSA transmission power and operation schedule for lunar orbiter control. Additional research was planned by determining the exact reception location, power measurement of the near-field region of the KDSA, redesigning the rectifier for an appropriate power level, and improving precision alignment control.