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PROPOSAL OF DESIGN METHOD FOR MAGNETIC RESONANCE COUPLING WIRELESS POWER TRANSMISSION MODULE USING DEPLOYABLE THIN FILM SPACE STRUCTURES

Abstract

The authors have proposed a deployable cubic structure, which can realize a structure from several tens of centimeters to several meters in scale, and a mission for a small satellite applied the deployable cubic structure. We are considering the mission of the wireless power transmission via magnetic resonance coupling within a satellite with flexible solar panels and printed coils on thin membranes attached to the side of the cubic structure. The aim of this wireless module is ease of use, as it requires only structural connections and no electrical connections between modules. If this wireless module can be realized, it will be one of the solutions to the harness problem, which was one of the bottlenecks of the deployable structure. Several studies on the magnetic resonance coupling system have demonstrated that highly efficient transmission can be achieved even though the coupling between coils is small in an impedance matching circuit. There is an experimental report of more than 95% transmission efficiency by the magnetic resonance coupling in an impedance matching circuit. In the author's mission, the impedance matching condition is expressed by the following equation. $\frac{(\omega_0 M)^2}{R_{RX}} = R_{TX}$, where ω_0 is resonance frequency, M is mutual inductance, R_{RX} is load resistance, and R_{TX} is input impedance. In addition, internal resistances of coils need to be small for highly efficient transmission. The purpose of this study is to build a design method for an appropriate coil shape and arrangement that satisfied the condition. When a coil is printed on a thin film, the shape of the solenoid coil is impossible. Therefore, the Archimedean spiral coil is adopted as of this moment. We found that a peak appeared in the mutual inductance value for a given arrangement even in the range of a small number of turns when a pitch of a coil with constant inner and outer diameters was varied, and confirmed that the shape asymmetry of the spiral coil was a factor. This result indicated the existence of an optimal coil shape that can increase the value of mutual inductance with a small number of turns. Furthermore, this study provides a method to design the optimal coil shape.