URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Investigation of Electromagnetic Energy Harvesting in Simple Square Patch Metasurface with Lumped Resistors

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The transmission of electromagnetic waves is increasingly being used as a communication medium with the rapid development of technology. Electromagnetic wave energy harvesting technology has a great opportunity to be developed and utilized. Variations in frequency, polarization, and angle of incidence of electromagnetic waves in the environment are important parameters to be considered in energy harvesting technology. A conventional rectenna consisting of a receiving antenna and a rectifying circuit usually operates at a predetermined polarization, angle of incidence, and frequency. Therefore, the limitations in harvesting electromagnetic wave energy are owned by a conventional rectenna.

Metamaterials have recently been proposed as an alternative to the conventional rectenna as an electromagnetic energy harvester. The metasurface is composed periodically of arrays of small electrical resonators called unit cells of the metamaterial. Good absorbing properties are achieved by properly designed metasurfaces, so that they are very attractive for use as an energy harvester of electromagnetic waves. [1]

In this study, a metasurface harvester is designed using 3 layers consisting of a resonator layer, a dielectric layer (substrate), and a ground plane. A simple square patch shape is used as the resonator layer. The metasurface harvester is designed and analyzed by using electromagnetic simulation. Boundary conditions used in the simulation are unit cells in the x and y-axis and open in the z-axis. The metasurface harvester is located in the x-y plane, and electromagnetic waves are radiated from the z-axis direction. The unit cell is excited by the Floquet port with transverse electric (TE) and transverse magnetic (TM) polarizations at the top boundary.

As a result, polarization-dependent characteristics of the electromagnetic energy harvesting metasurface are obtained in three models using a single via. In the first model, a lumped resistor is placed between the resonator layer and the ground plane through a harvesting via. In the second model, a lumped resistor is placed between the resonator layer and the ground plane through the harvesting via which is made like a coaxial SMA connector. In both the first and second models, a lumped resistor is placed under 3 different conditions: (1) the direction of the lumped resistor is parallel to the x-axis, (2), the direction of the lumped resistor is parallel to the y-axis, and (3) two lumped resistors are placed in the x-and y-directions. In the third model, a lumped resistor is placed in a standing position between the via and the ground plane. The results of the three models are analyzed in terms of the shape of surface current excited by the incident electric field polarization, and their harvesting efficiency is evaluated. This could be used as a guide for designing simple but efficient electromagnetic energy harvesting metasurfaces.

Reference

[1] F. Yu, X. Yang, H. Zhong, C. Chu, and S. Gao, "Polarization-Insensitive Wide-Angle-Reception Metasurface with Simplified Structure for Harvesting Electromagnetic Energy," *Appl. Phys. Lett.* **2018**, 113, 123903, doi.org/10.1063/1.5046927.