A Metamaterial-Based Energy Harvester Design for Enhanced Power Supply to Wireless Sensor Network

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ABSTRACT

Health sensing module in prognostics and health management (PHM) requires accurate acquisition of sensory signal and optimal deployment of sensor nodes. To this end, wireless sensor network (WSN) is widely utilized by virtue of the ease of the sensor deployments and the advances in the wireless communication. However, periodic replacements of the batteries are demanded for continuous operation of the WSN, which incurs additional costs and temporary suspension. To overcome these drawbacks, vibration energy harvesting (VEH) has emerged as a possible solution to realize self-powered/sustainable WSN operation. The VEH converts ambient vibration into electric power through an energy conversion medium. Low output power density, however, is still a critical issue in the VEH for its feasible application. Metamaterial-based energy harvesting (MBEH) has recently been proposed as a breakthrough technology to drastically improve output power generation. Metamaterials are engineered structures to exhibit exotic properties such as a bandgap. The bandgap refers to a certain frequency range within which elastic waves are prohibited to propagate. It can be used to enlarge elastic wave energy going into the energy conversion medium. While various mechanism for the MBEH has been introduced, only a few research has considered detail factors that can degrade the metamaterial's performance. In this study, we propose a new phononic crystal design which prevents wave cancellation to improve the metamaterial's performance. In building the model, the multiphysics finite element method are used to analyze dispersion and energy harvesting performance. Finally, the energy harvesting performance of the proposed design is compared with the design without the consideration of the wave cancellation.