Dynamic Analysis of a Transient Plucking Energy Harvester towards Battery-free Motion-Sensing System

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Abstract:

This paper introduces a transient plucking energy harvester towards a battery-free motion-sensing IoT system. A piezo-magneto-elastic system composed of a low-cost piezoelectric cantilever and a pair of magnets is used to form a plucking mechanism for high-efficient energy harvesting in response to a transient external excitation. Instead of investigating the frequency-up conversion and expecting a continuous power supply from the harvester, we give a comprehensive analysis to explore how much energy the harvester can capture from the single plucking motion. The energy flow transformations with the potential energy pre-charging, the varying potential energy pictures during the plucking process, and the dynamic behaviors under the influence of different magnet layouts are numerically investigated. Moreover, we implemented a prototype ViPSN-pluck based on a co-design considering the cyber-electromechanical synergy. Only one plucking can fulfill the tasks of motion direction detection and wireless transmissions. The proposed ViPSN-pluck provides valuable guidance towards the design of kinetic energy harvesting IoT systems.

Keywords: vibration energy harvesting; plucking; bistable; transient; battery-free IoT

1. Introduction

Energy harvesting has emerged as a promising power solution for Internet of Things (IoT) systems via leveraging ambient energy sources such as solar, radio frequency (RF), and vibration. Free from chemical batteries, these energy harvesting-powered IoT systems are not only self-sustaining and maintenance-free, but also eco-friendly [1]. They have been deployed in many application domains, such as infrastructure monitoring, in-body medical sensing, and space exploration. In particular, kinetic energy in the form of vibrations, random displacements, or forces is ubiquitous