Optimization of Hybrid Energy Harvesting using Finite Element Analysis

Nik Nurul Husna Binti Muhmed Razali\textsuperscript{1}, Ahmad Razlan Yusoff\textsuperscript{1,}\textsuperscript{*}
\textsuperscript{1} Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia

In this paper, the main objective is to optimize energy harvesting design of piezoelectric and magnetic based on vibration excitation. An alternative method for predicting the power output of a bimorph cantilever beam using finite element method with the harmonic analysis solver. Both power output generated from the electromagnetic and the piezoelectric was combined to form one unit of energy. In addition, the optimum model was analyzed using parametric optimization analysis solver in finite element analysis to produce optimum power output. The result showed the maximum power output generated of 56.66 $\mu$W from 47.94 Hz, 4.905 m/s$^2$ and 0.18 cm$^3$ for resonance frequency with acceleration and volume. The decreasing size of harvester with a low natural frequency for producing high power output.

Keywords: Piezoelectric, Electromagnetic; Finite Element Method.

1. INTRODUCTION

Modern developments in electronic technology have qualified a decrease in both size and power consumption of complex digital systems. It is highly desirable for wireless sensor nodes to be self-powered\textsuperscript{1}. Basically, the process for capturing energy from an ambient energy and converting into usable electric power refers to energy harvesting. According to Beeby\textsuperscript{2}, a renewable power source can be used to directly replace the battery. The most common ambient sources for energy harvesting are photonic, thermal, and vibration. The technique of the hybrid has become more popular for the development of the energy harvesting devices. Hybrid energy harvesting devices is combination of more than one of the energy scavenger systems to create a more efficient unit. Ali et al.\textsuperscript{3} specified the performance of hybrid system harvester using series and parallel configuration of piezoelectric-electromagnetic by varying the resistance load. However, Thein et al.\textsuperscript{4} presented a new method to optimize a bimorph piezoelectric cantilever beam for capitalizing on power output and reducing structural volume. The design of a cantilever beam with two magnets attached to a C-shaped core could increase the natural frequency of the system up to 322 Hz was proposed by El-Hami et al.\textsuperscript{5}. Duffy et al.\textsuperscript{6,7} created an electromagnetic energy harvester that consists of two fixed magnets at each end of the device which acts as the springs. It was found that the induced voltage is proportional to the increment of the number of turns and the length of beams. Thus, a mechanical stopper was contacted to a cantilever beam to increase the range of operation was presented by Soliman et al.\textsuperscript{8}. In 2001, White et al.\textsuperscript{9} were conveyed the alternative way of scavenging the energy using the piezoelectric. By applying stainless steel tapered base with two layers of piezoelectric film printed on both sides, the deflection of the piezoelectric layers can be maximized and apparently increase the power output. In addition, Yu et al.\textsuperscript{10} generated more power output by using a combination of two devices rather than a stand-alone device. The output voltage is increased by using the MEMs PZT cantilever array architecture\textsuperscript{12}. Consequently, a model consisted of a piezoelectric cantilever beam with a tip mass and magnets on both

\textsuperscript{*}Email Address: razlan@ump.edu.my