Optimum Design of a Multi-Modal Vibration Energy Harvester

By

Mina Refaat Roushdy Dawoud Mikhail

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE in
MECHANICAL DESIGN AND PRODUCTION ENGINEERING

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Title of Thesis:

Optimum design of a Multi- Modal Vibration Energy Harvester

Key Words:

Energy harvesting; Optimization; Multi-modal energy harvesting.

Summary:
This work presents the design and optimization of a multi-modal vibration energy harvester to enable extracting energy from wideband excitations. The harvester consists of a tapered cantilever beam having a straight longitudinal slit that extends from the beam tip, partially dividing the beam into two sub-beams. Each sub-beam carries a proof mass and a permanent magnet at its tip. The two permanents magnets oscillate past stationary coils in order to convert the mechanical motion into electrical energy. The main system design variables, namely the beam geometry, slit length, mass values and their positions affect the harvester's natural frequencies and output power. The beam is optimized to exhibit four closely-spaced natural frequencies with comparable output power levels from each mode in order to obtain efficient operation across a desirable bandwidth. A finite element model is developed to predict the dynamic performance of the beam under harmonic excitation. A genetic algorithm and two objective functions are used to obtain optimized values of the design parameters. Findings of the analytical model are verified experimentally.

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