PREFACE

Low power sensors are used in the tire pressure monitoring system (TPMS) configuration, real-time condition monitoring of turbine and propeller blades, so as for active vibration isolation of structures. The reliability of those sensor systems mainly depends on their power sources. The conventionally used electrochemical batteries have some severe disadvantages, including environmental and frequent maintenance problems. Therefore, developing a device that can harvest the remotely available abundant ambient energies and supply power to those sensors will be advantageous. The piezoelectric transduction method always provides higher efficiencies while using compact structures. The first part of the thesis provides a brief background of piezoelectricity and general piezoelectric vibration energy harvesting (PVEH) systems and the novel contributions to the existing knowledge this thesis intends to make.

Then an in-depth, comprehensive literature review is conducted to summarize the past published work related to the thesis goals. This begins with a brief background on energy harvesting applications and necessity, which is followed by a review of the piezoelectric material and mathematical modeling techniques for tapering cross-section PVEHs. Following the literature review, the research gaps related to the harvester's shape, mathematical modeling, and experimental analysis are identified.

The consequent chapters present; (1) An experimentally validated full nonlinear model of a novel parabolic tapering width base excited PVEH. The geometric and material nonlinearities are considered in the form of nonlinear piezoelectric constitutive relation, electric displacement relation, and strain-displacement relation. (2) The design and validation of parabolic and exponentially tapering width PVEHs for rotational motion applications. The ANSYS Mechanical APDL simulations and experimental methods are used to validate the mathematical models of the two rotational piezoelectric vibration energy harvesters (RVEH). (3) A parametric analysis of the proposed parabolic and exponentially tarping width RVEH. The first part discusses the effects of taper parameter, piezoelectric patch to host beam thickness ratio, harvester's length, and the overall radius of rotation on the RVEH's OC voltage responses and voltage-per-total mass (VPM). The second part presents the effects of these parameters on the exponentially tapering RVEH's frequency responses along with the OC voltage and VPM.

Finally, the findings of the research, highlighting the novel and original contributions, are presented. The suggestions for future research to extend this study are also discussed.