

Table of Contents

Abstract	3
Acknowledgements	5
Table of Contents	7
List of Figures	8
List of Tables	9
1. Introduction	11
1.1 General Idea of MEMS Energy Harvester	11
1.1.1 Electrostatic Energy Harvester	11
1.1.2 Electromagnetic Energy Harvesting	12
1.1.3 Piezoelectric Energy Harvesting	12
1.2 Important Factors Regarding Power Measurement and MEM Design	13
1.2.1 Linear MEMS System	13
1.2.2 Nonlinear MEMS System	14
2. Design of the Test System	17
2.1 Overall Layout of the Text System	17
2.2 Details Regarding the Charge Amplifier	18
2.3 Details Regarding the Charge Amplifier	18
2.4 Details Regarding the DAQ Board	20
3. Experimental Evaluation	21
3.1 Specifications of Energy harvester Device	21
3.2 Open Circuit Measurements for the Energy Harvester	23
3.3 Theoretical Calculation of Power	28
3.4 Experimental Calculation of Power	30
4. Summary and Conclusion	33
5. Appendices	35
Appendix A: LabView Setup	33
Appendix B: ET-126 Shaker Specifications	39
Appendix C: Charge Amplifier Specifications	41
6. Bibliography	49

List of Figures

Figure 1-1:	Possible topologies for MEMS-scale electrostatic energy harvester	11
Figure 1-2:	Mechanical schematic of a typical electromagnetic energy harvester	11
Figure 1-3:	A diagram of a cantilever beam harvester with a proof mass	12
Figure 1-4:	Graph of transmissibility	12
Figure 1-5:	Bending and stretching of a double clamped beam	14
Figure 1-6:	Deflection vs. frequency for a nonlinear system	15
Figure 2-1:	Diagram of the overall layout of the test bench	17
Figure 2-2:	Test bench layout with labeled machinery	18
Figure 2-3:	Test bench layout with labeled machinery	19
Figure 2-4:	Energy harvester mounted on the shaker	18
Figure 2-5:	Input and output chord of the charge amplifier	19
Figure 2-6:	S000B-100A charge amplifier with a gain of gain of 100mV/pC	19
Figure 3-1:	Diagram of V21BL energy harvester; measurements are in inches	21
Figure 3-2:	Layers of V21BL	22
Figure 3-3:	Graph that shows the relationship between natural frequency and proof mass	22
Figure 3-4:	Positive and negative nodes of the energy harvester connected to clamps	23
Figure 3-5:	Green wire inserted in Input1 and black wire in Ground of the DAQ board	24
Figure 3-6:	Diagram of overall layout of the test bench without charge amplifier	24
Figure 3-7:	Open circuit voltage measured at 67Hz	25
Figure 3-8:	Plot of open circuit voltage vs: frequency for a V21BL	27
Figure 3-9:	Series circuit with voltage source and internal and external impedance	28
Figure 3-10:	Pattern seen from plotting P_{ext} (Z_{ext}) function	29
Figure 3-11:	Resistor connecting the positive and negative nodes of energy harvester	30
Figure 3-12:	Graph that plots power vs. resistance data from table 3-2	31

List of Tables

TABLE 3-1: Open circuit voltage created by the energy harvester	26
TABLE 3-2: Power values calculated from the resistance swap	31