SCHOOL OF ENGINEERING

Increasing Bandwidth of Kinetic Meso-Scale Energy Harvesters using Parachute-Based Proof Mass

3D printing energy applications

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Collaboration: Nico E. Galarza

CHRES CONSORTIUM OF HYBRID RESILIENT ENERGY SYSTEMS DE-NA0003982

About Me

What I am study?
Electrical Engineering

Where I am study ?
Ana G. Mendez Recinto
Gurabo

Hobbies:
- Read books
- Go to the beach
- Work with microprocessor to do robots and learn how to use sensor and actuators.



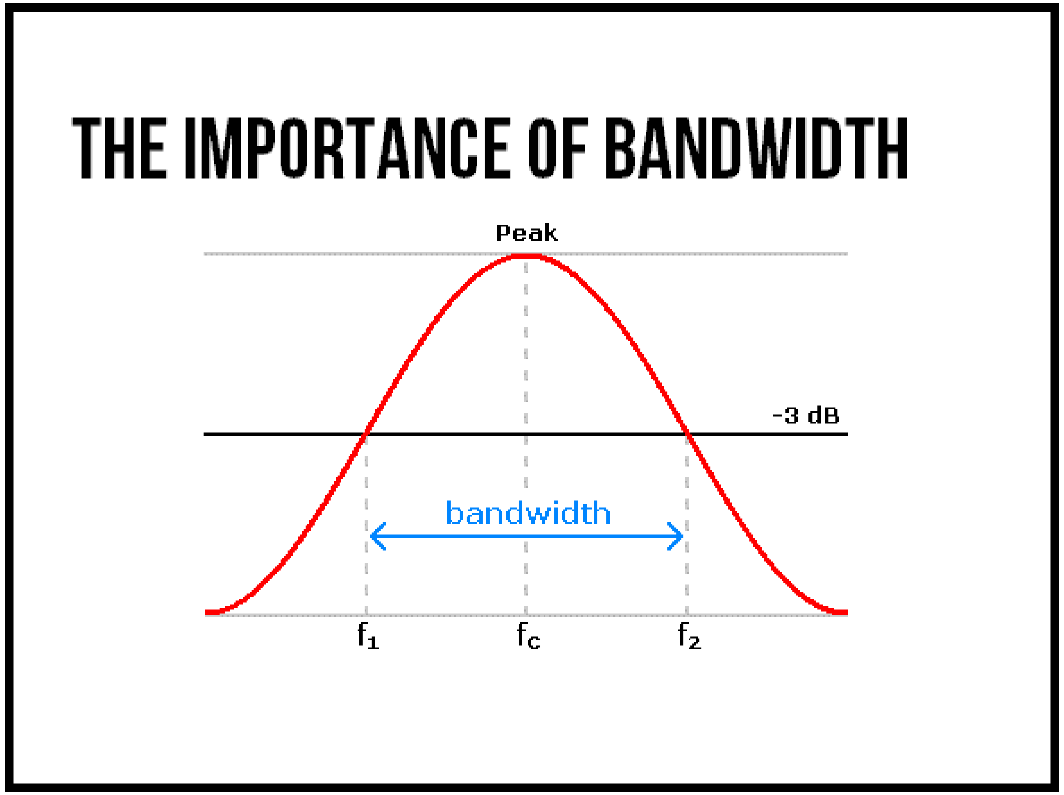

Abstract: This research focuses on the testing and evaluation of various 3D printed structures, using PLA material, within the paradigm of the parachute method. The goal is to examine the capability of these designs to increase the bandwidth, especially in relation to different materials used for parachutes. The research has been focused on contrasting cantilever structures and 3D printed designs, to evaluate how each contributes to improving the bandwidth of the piezoelectric by using different materials. The data presented in this research represents only the bandwidth of the 3D printed structures, to facilitate clear comparisons. The results of my 3D designs coupled with the materials used as parachutes will be presented by my collaborator in this research.

Objective: The central Objective of this research lies in the comprehensive optimization of the bandwidth of piezoelectric devices. This is achieved through the analysis and application of the parachute method, employing 3D printed components and a variety of materials used as parachutes, with the goal of enhancing the increase in bandwidth.

Why Research Piezoelectric Device

- Development of Piezoelectric Materials
- Harnessing Vibrations in Large Structures
- Automotive Applications
- Improvement of Domestic Smoke Sensors
- Future of Piezoelectricity

Why increase the bandwidth



- **Need for Greater Versatility**
- **Optimization of Frequency Range**
- **Tuning System**
- **Conversion of Mechanical to Electrical Energy**

Solo cantilever Piezoelectric Specifications

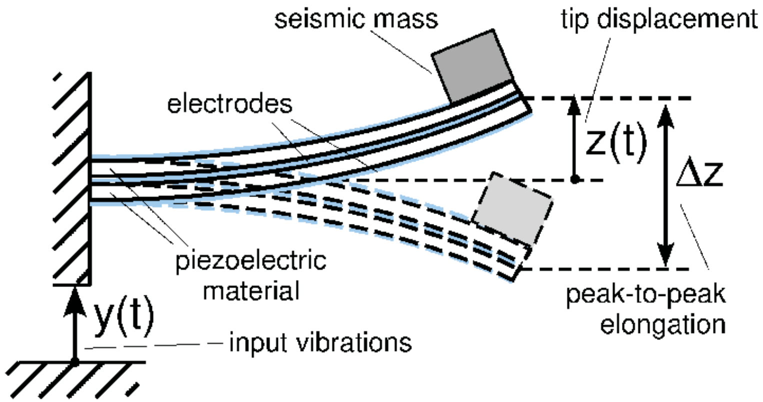


Figure 1: Cantilever movement

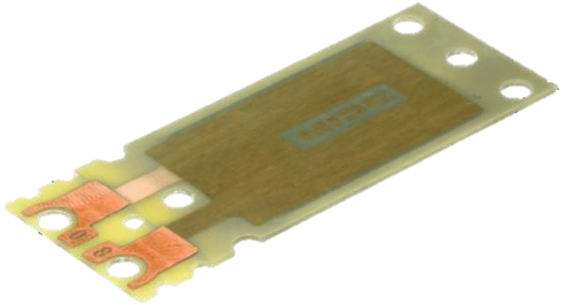


Figure 2: Piezoelectric

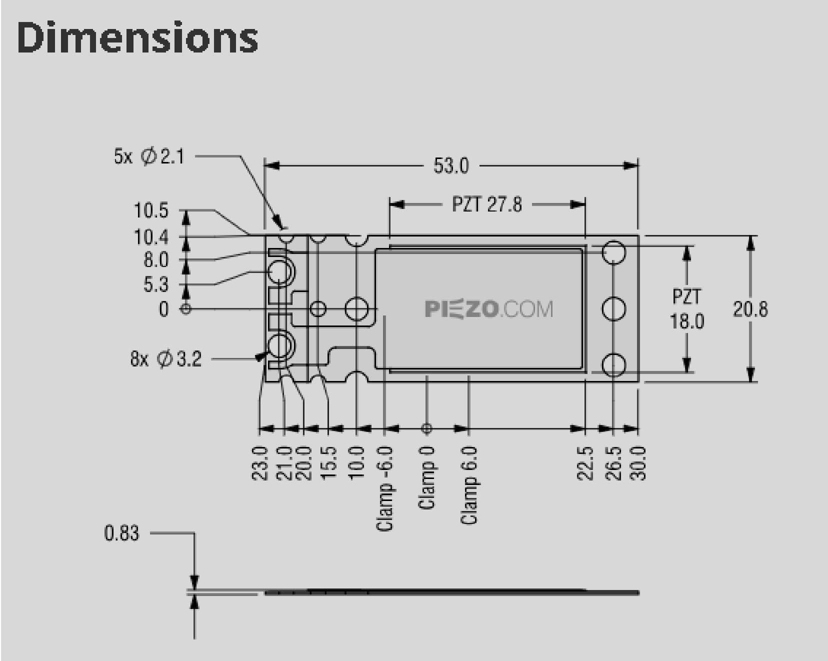


Figure 3: Piezoelectric Dimensions

Layer Specifications

Layer Material	Thickness mils / mm
FR4	3.0 / 0.08
Copper	1.4 / 0.03
PZT 5H	7.5 / 0.19
Copper	1.4 / 0.03
FR4	3.0 / 0.08
Copper	1.4 / 0.03
PZT 5H	7.5 / 0.19
Copper	1.4 / 0.03
FR4	3.0 / 0.08

Figure 4: Piezoelectric Layer specs

Solo Cantilever Piezoelectric Data

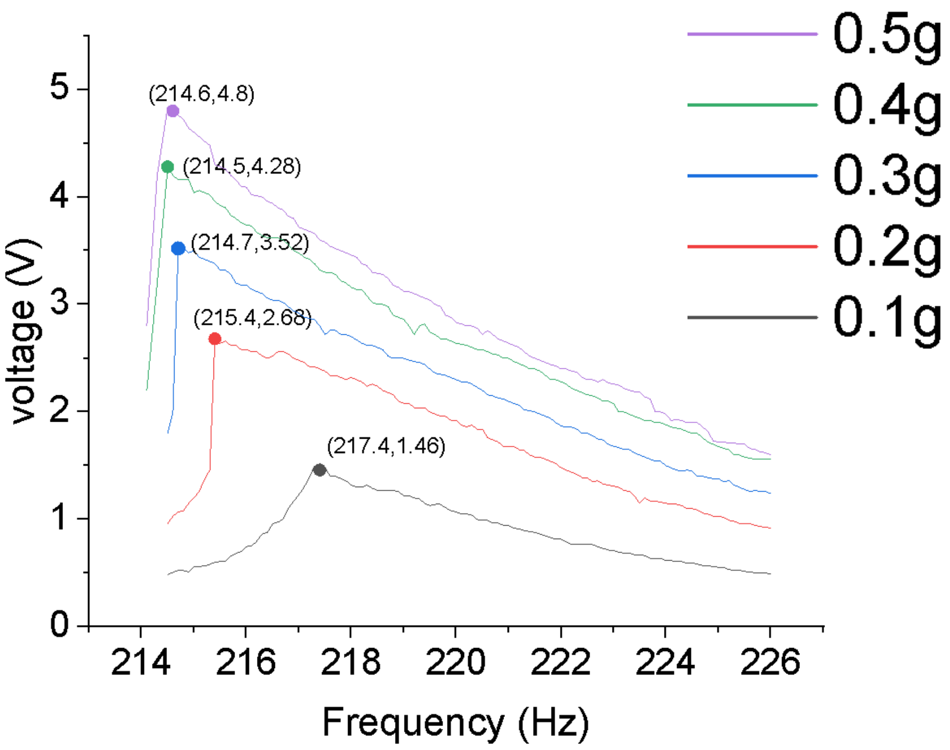


Figure 5: Voltage vs Frequency Cantilever

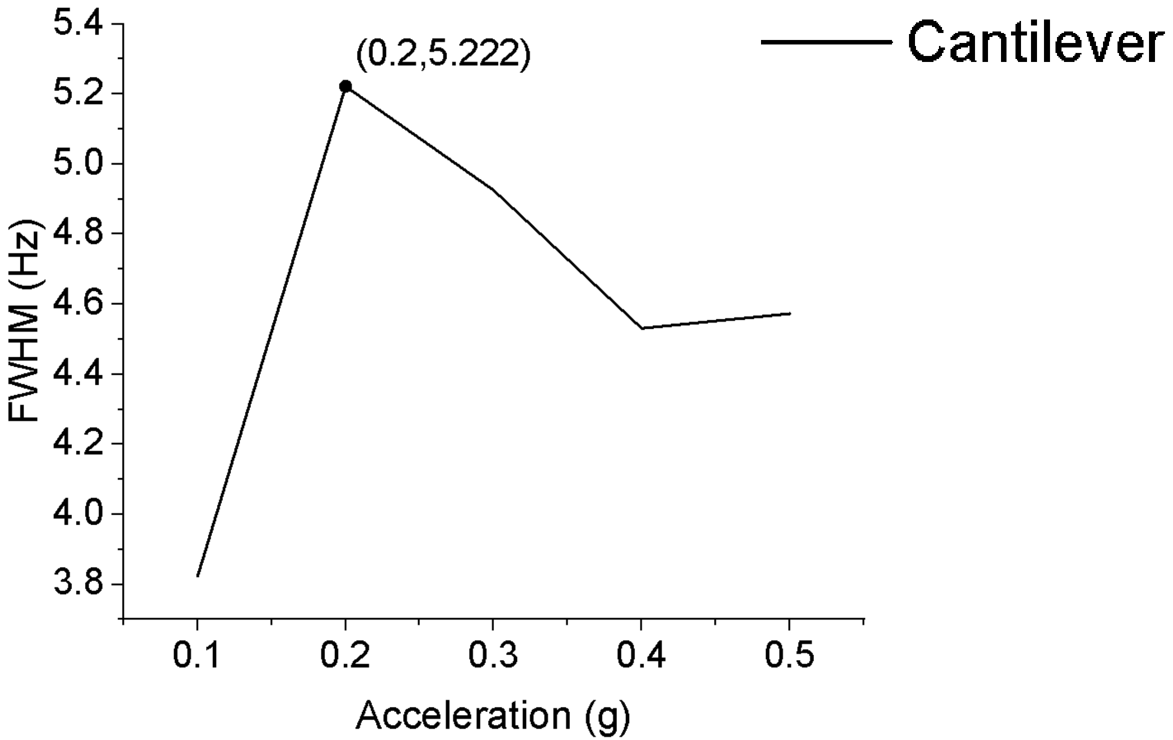


Figure 6: FWHM vs Acceleration Cantilever

Triple Holes P-mass Specifications

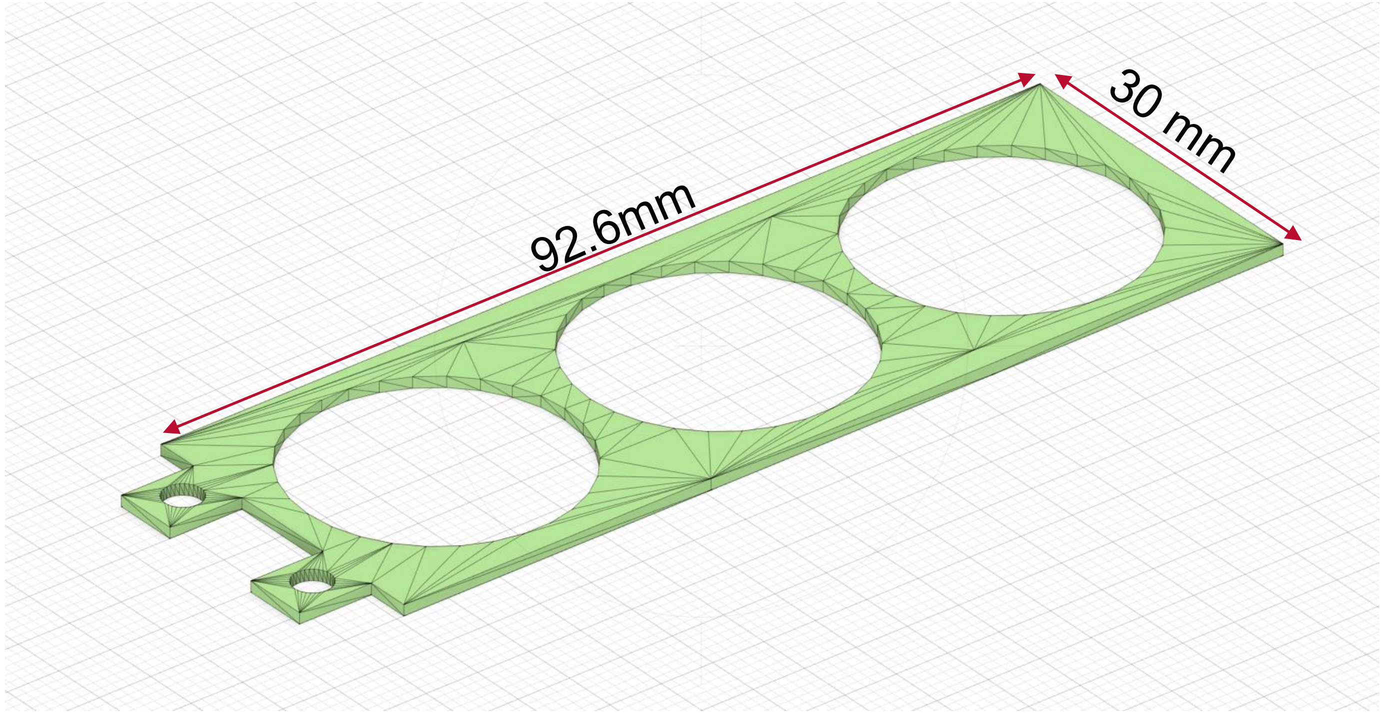


Figure 7: Triple Holes P-mass

- 1 mm Thickness
- 25 mm Diameter per hole
- 92.6 mm Length
- 30 mm Width
- Weight1 .69g

Triple Holes 1mm P-mass Data

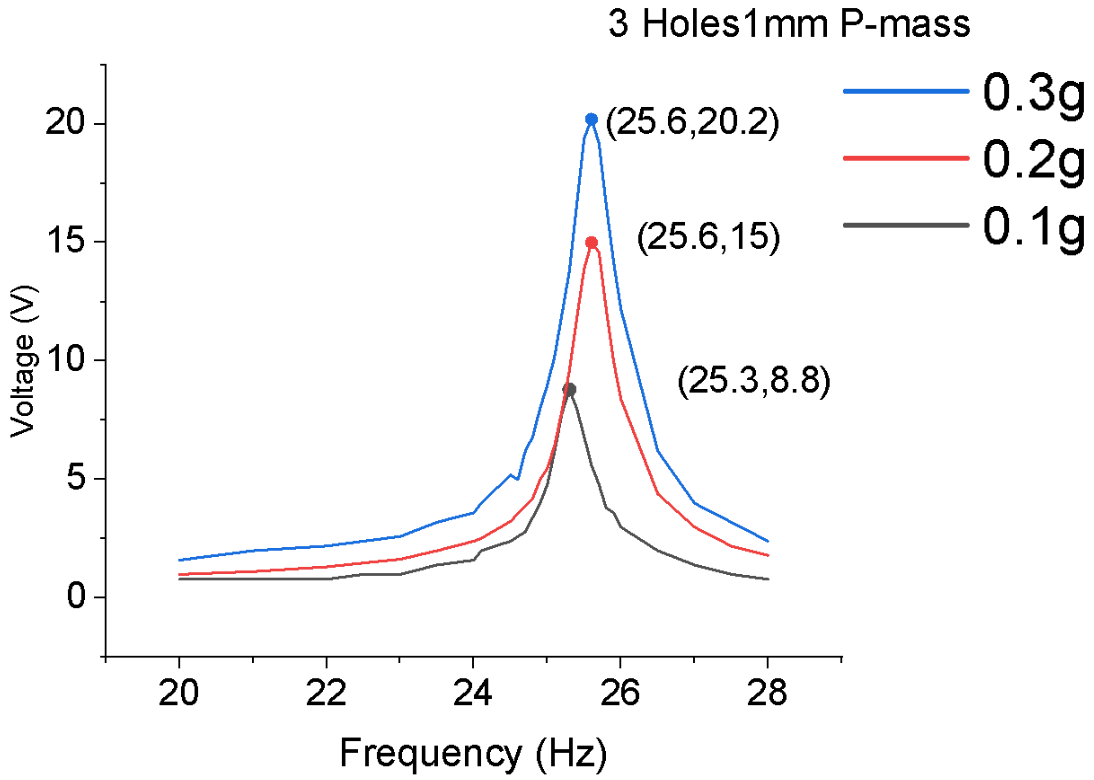


Figure 8: Voltage vs Frequency Triple Holes P-mass 1mm

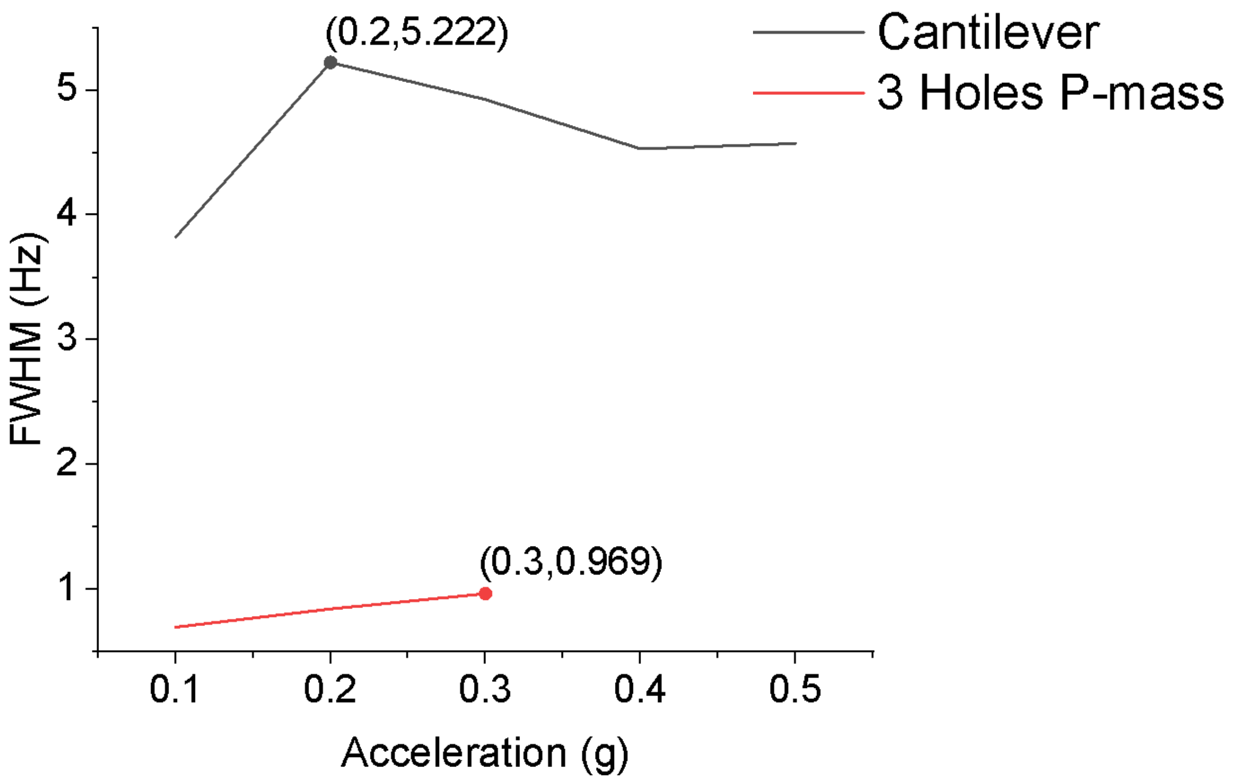
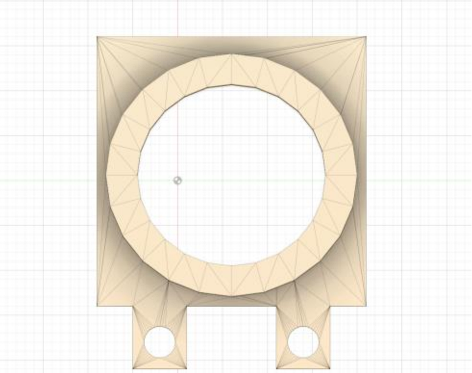


Figure 9: FWHM vs Acceleration Triple Holes P-mass 1mm

Cylindrical P-mass Specifications

- 5 mm Thickness Cylindrical
- 1 mm Thickness Base
- 25 mm Diameter per hole
- 37 mm Length
- 30 mm Width
- Weight 2.12g



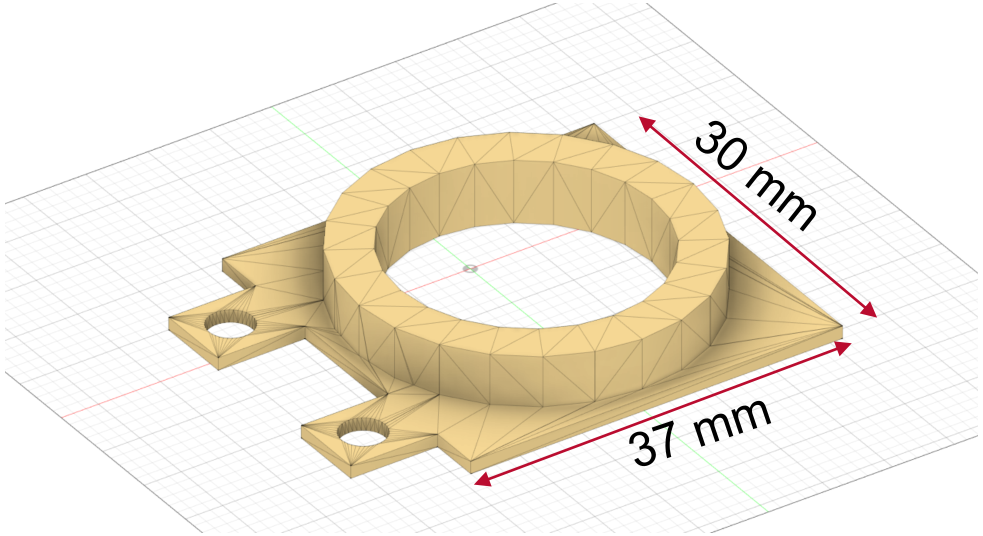
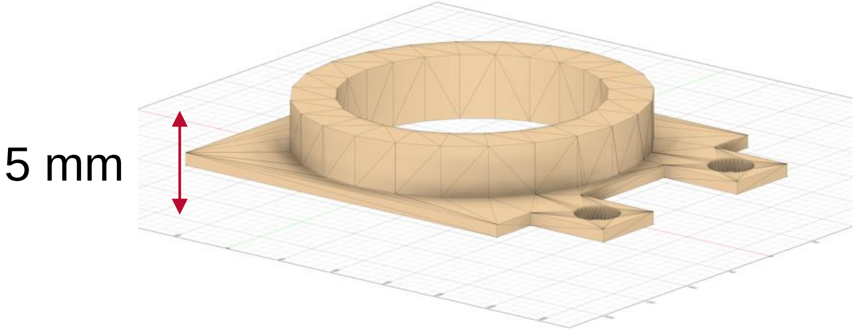


Figure 10: Cylindrical P-mass



Cylindrical P-mass Data

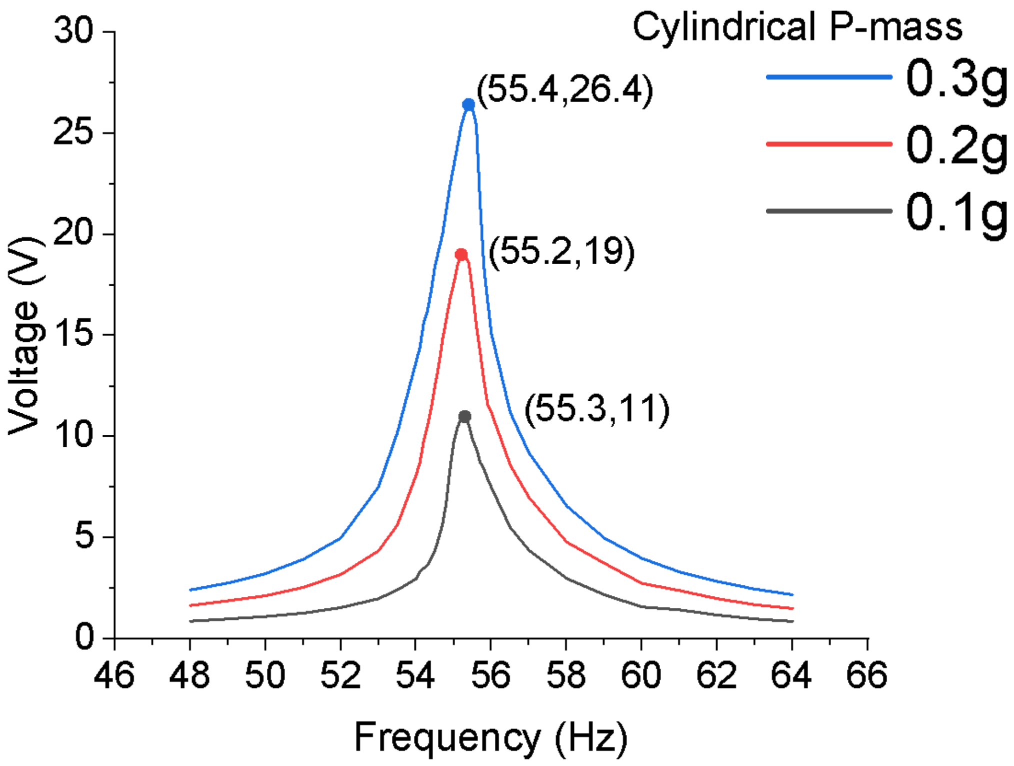


Figure 11: Voltage vs Frequency Triple Cylindrical P-mass

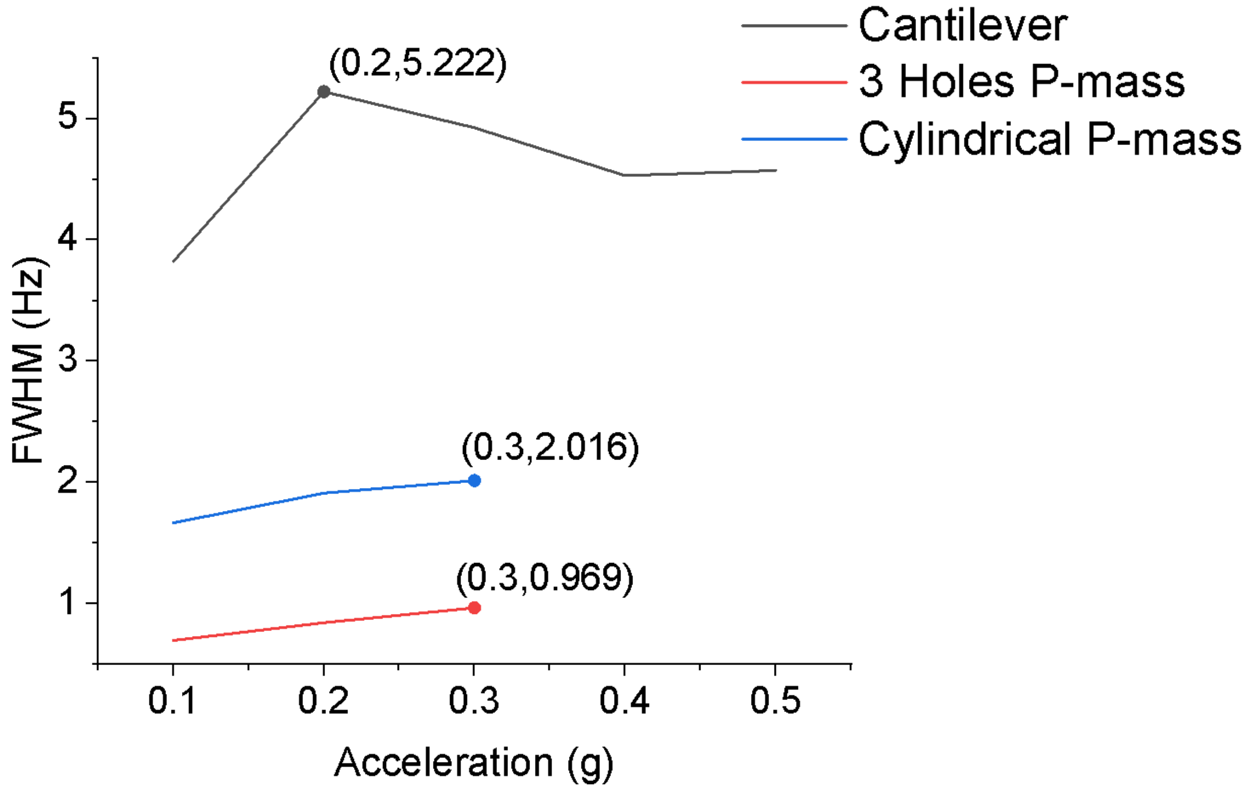


Figure 12: FWHM vs Acceleration Cylindrical P-mass

Wide P-mass Specifications

- 5 mm Thickness
- 33 mm Length
- 67.1 mm Width
- Weight 2.6g

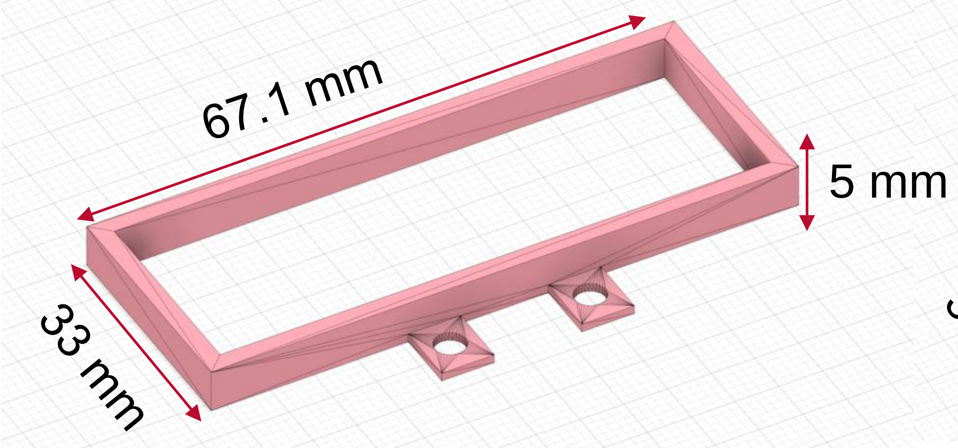


Figure 13: Wide P-mass 5mm

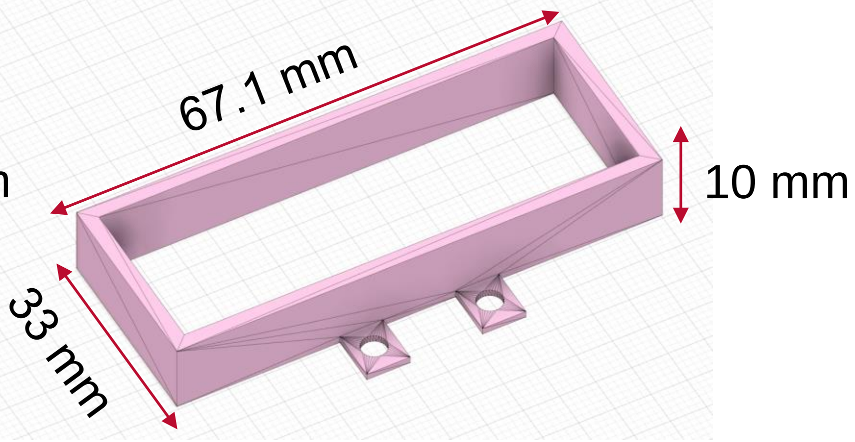


Figure 14: Wide P-mass 10mm

- 10 mm Thickness
- 33 mm Length
- 67.1 mm Width
- Weight 4.87g

Wide 10mm P-mass Data

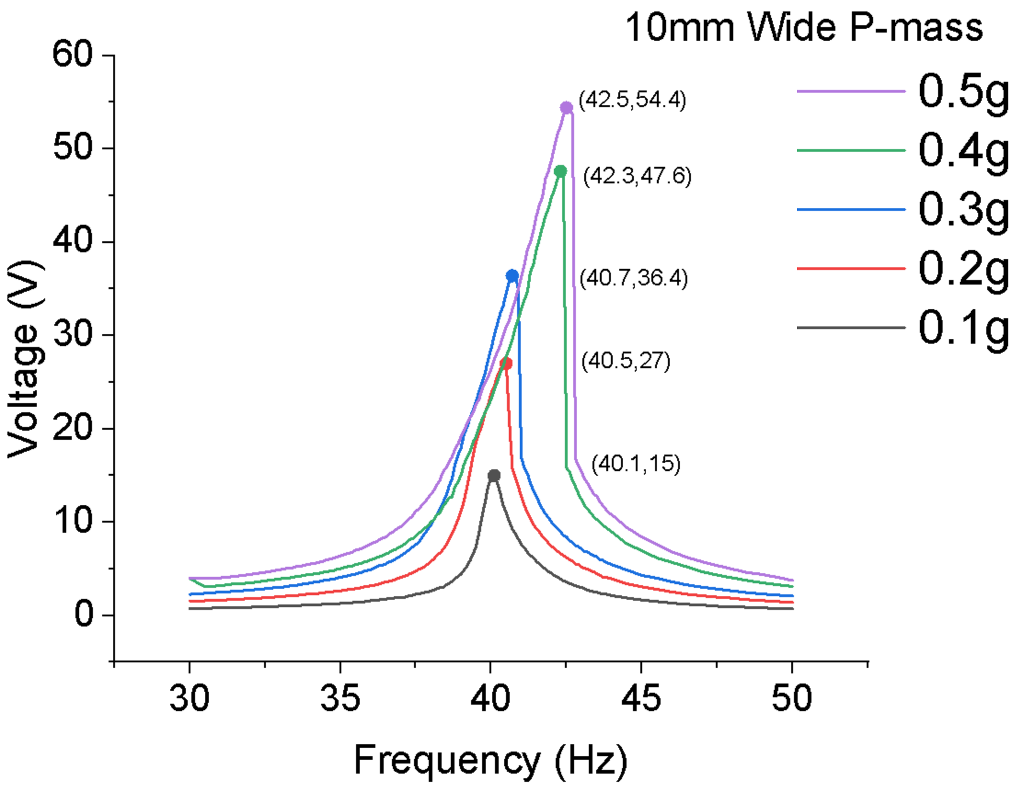


Figure 15: Voltage vs Frequency Wide 10mm P-mass

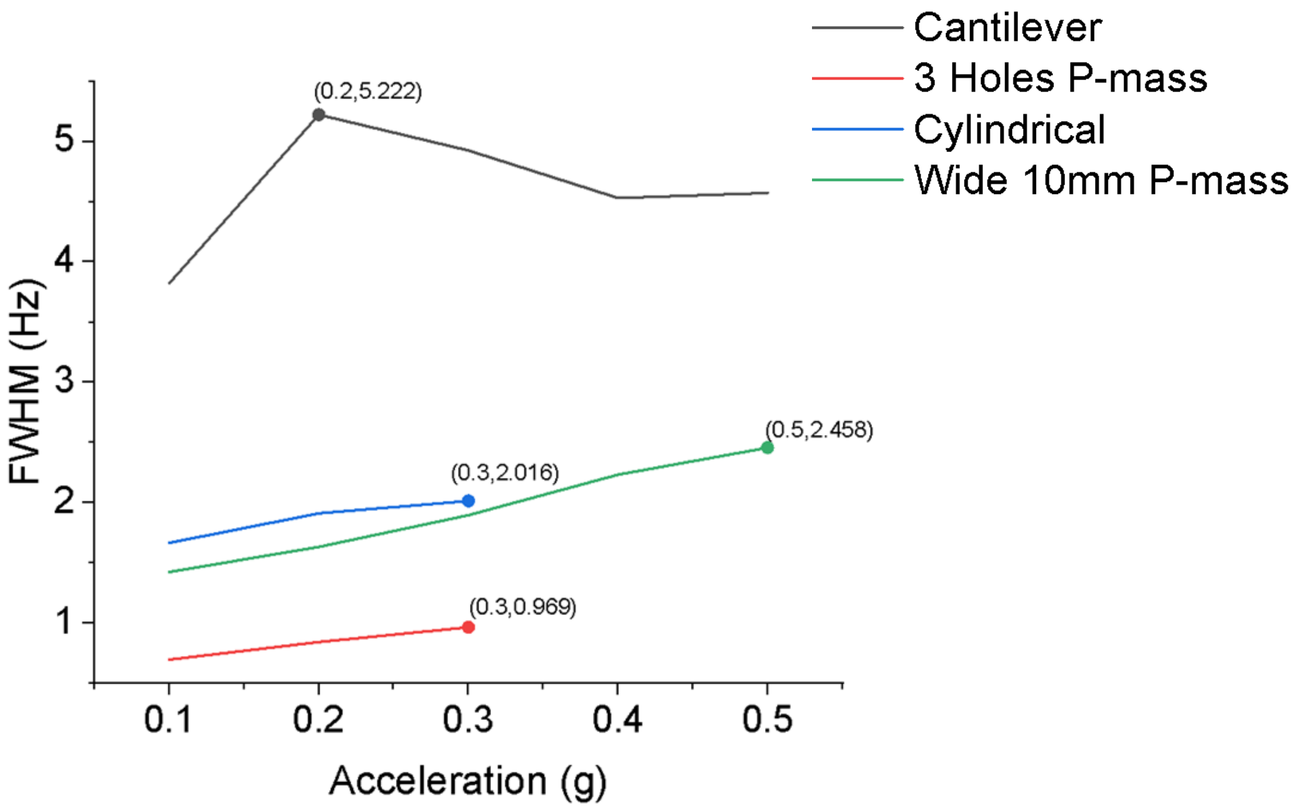


Figure 16: FWHM vs Acceleration Wide 10mm P-mass

Wide 5mm P-mass Data

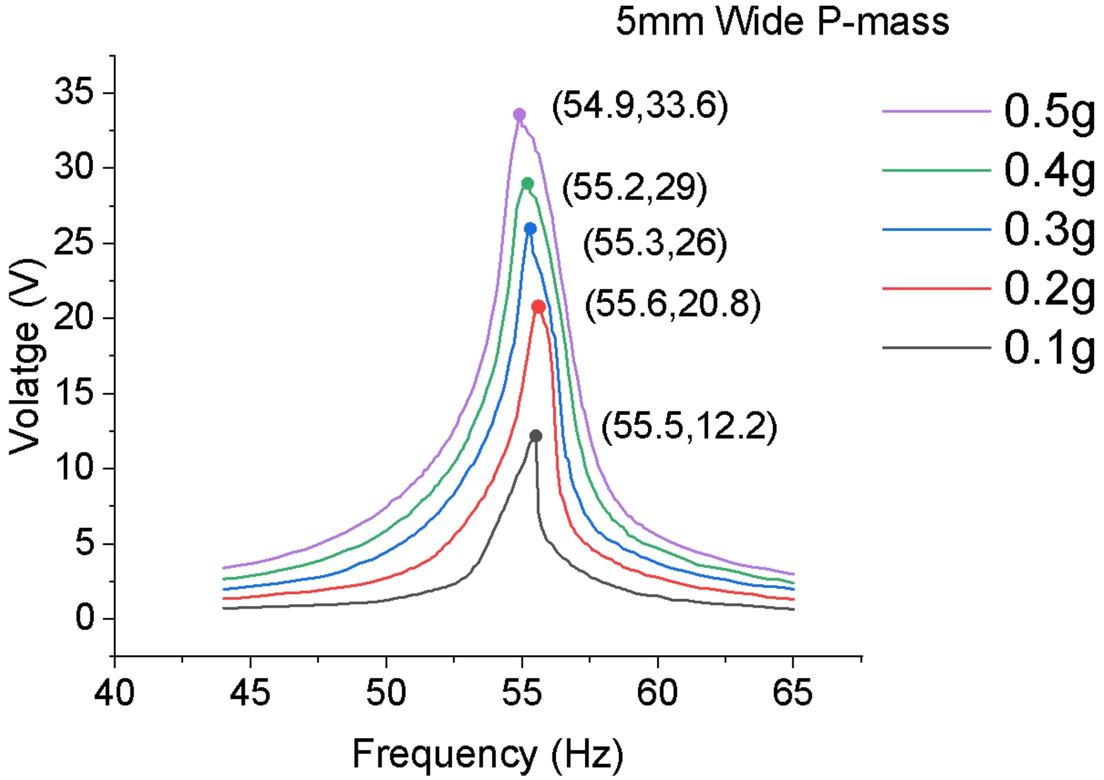


Figure 17: Voltage vs Frequency Wide 5mm P-mass

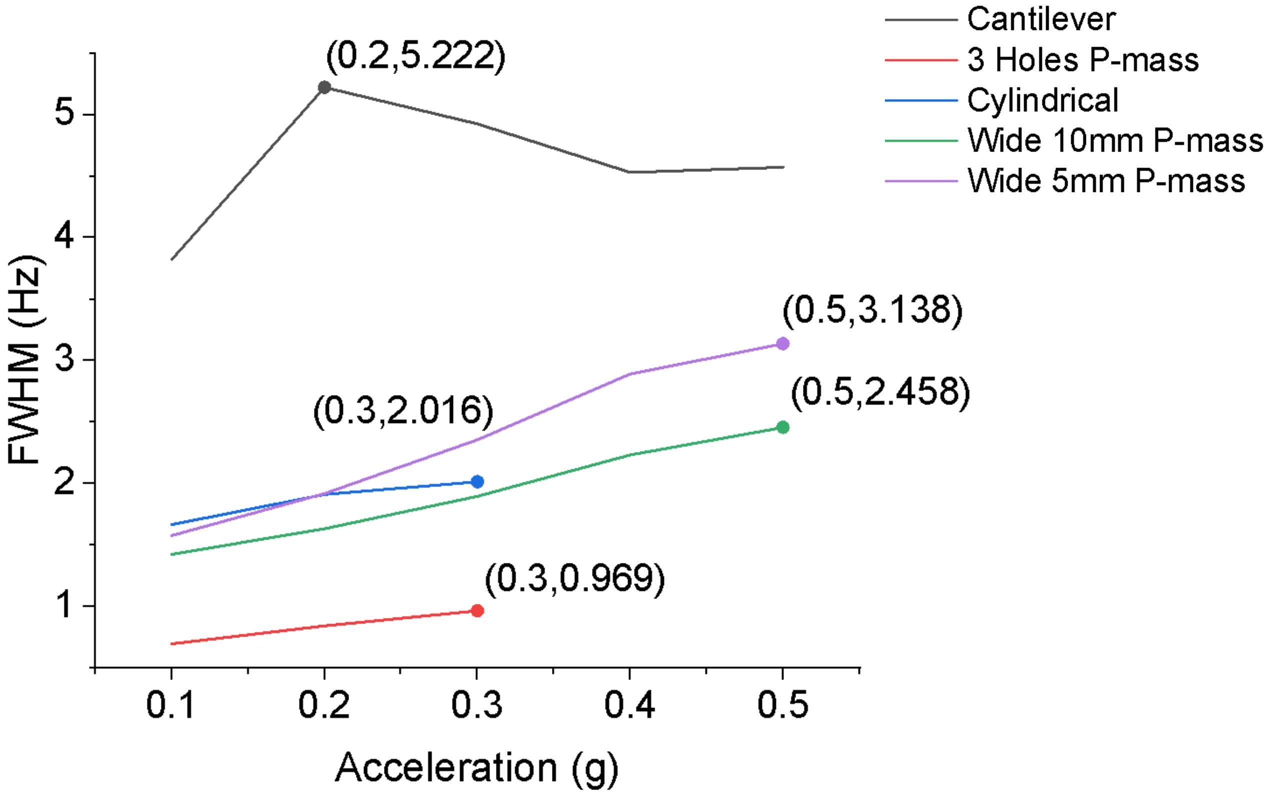
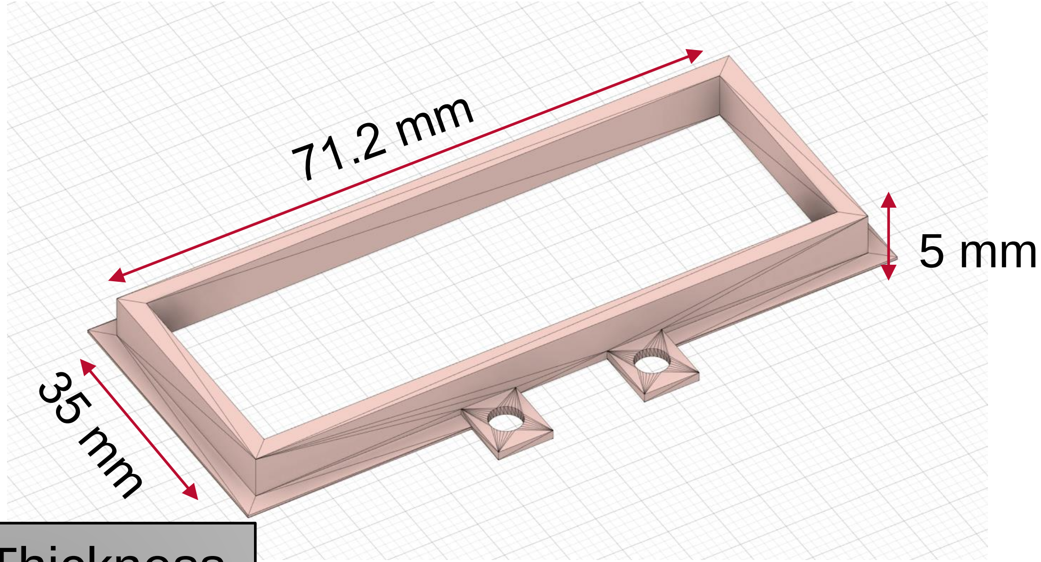
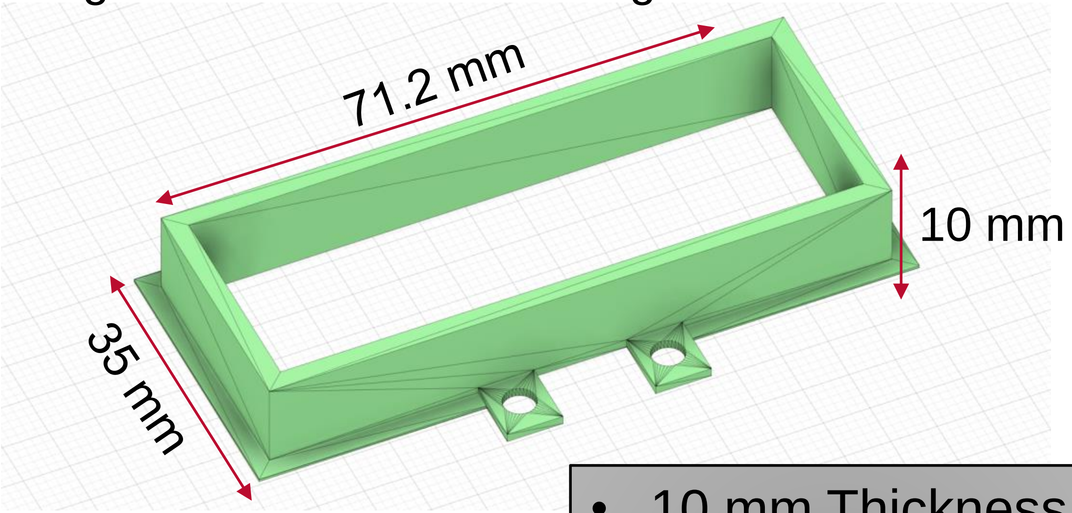


Figure 18: FWHM vs Acceleration Wide 5mm P-mass

Wide P-mass Edge Specifications

Figure 20: Wide P-mass Edge 10mm P-mass





- 10 mm Thickness
- 35 mm Length
- 71.2 mm Width
- Weight 5.2g

- 5 mm Thickness
- 35 mm Length
- 71.2 mm Width
- Weight 2.9g

Figure 19: Wide P-mass Edge 5mm P-mass

Wide 10mm P-mass Edge Data

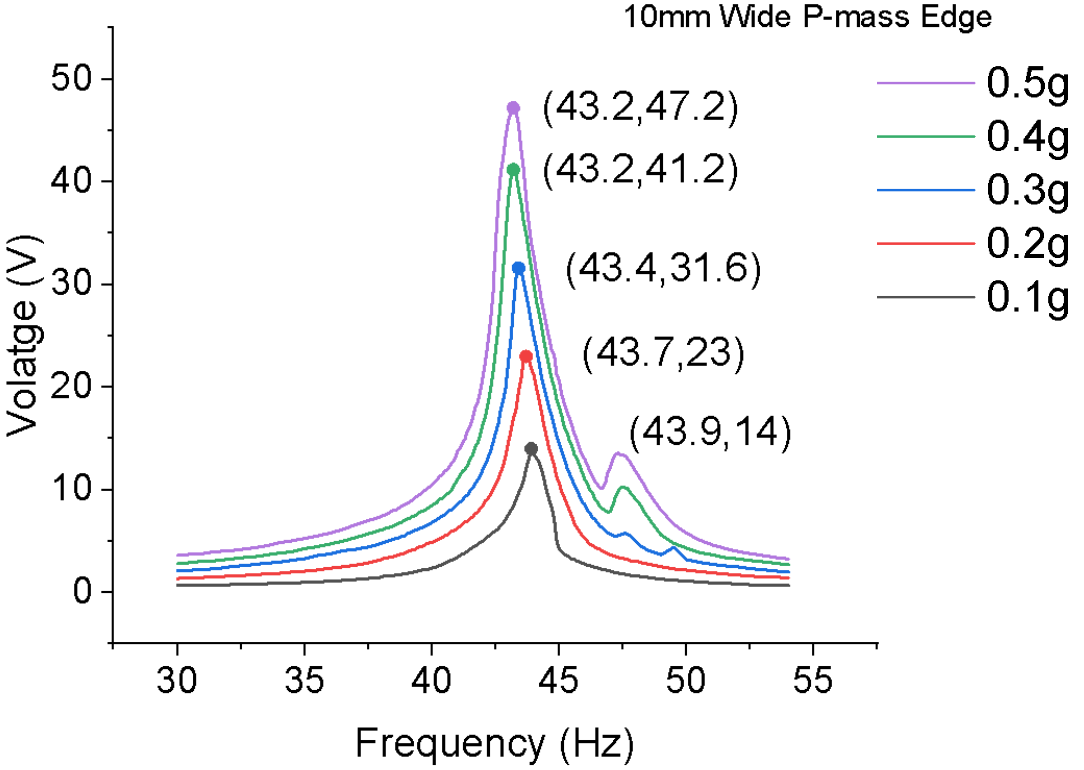


Figure 21: V vs Hz Wide 10mm P-mass Edge P-mass

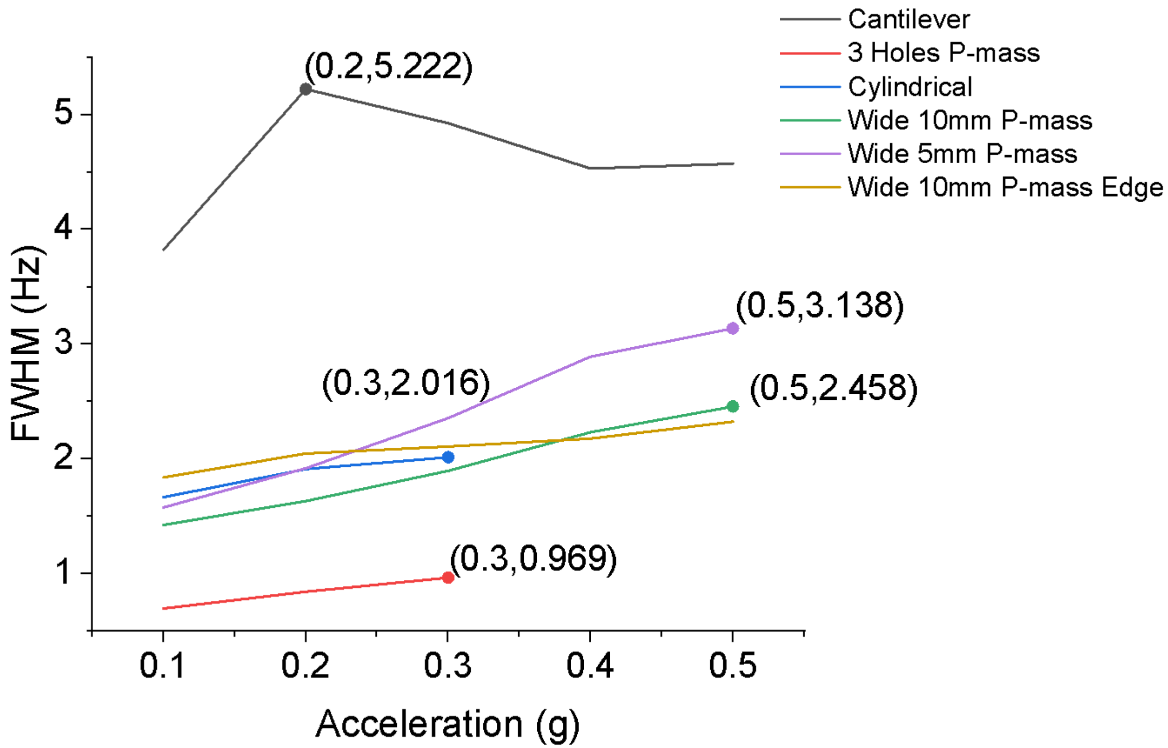


Figure 22: FWHM vs Acceleration Wide 10mm P-mass Edge P-mass

Wide 5 mm P-mass Edge Data

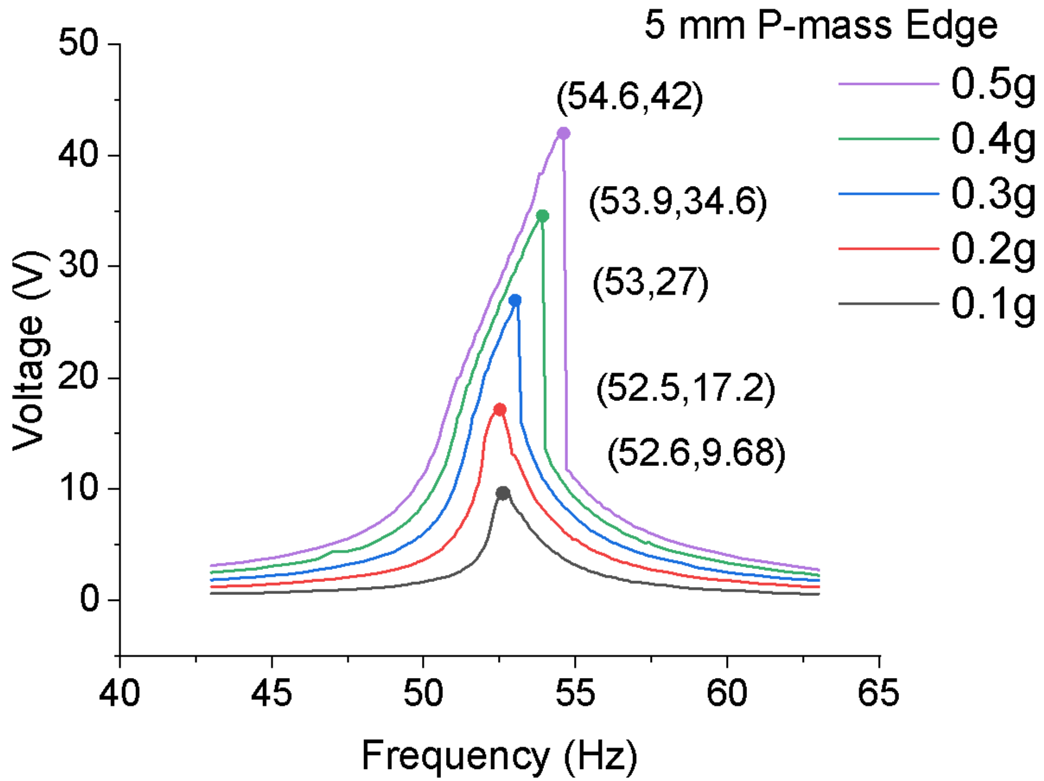


Figure 23: V vs Hz Wide 5mm P-mass Edge P-mass

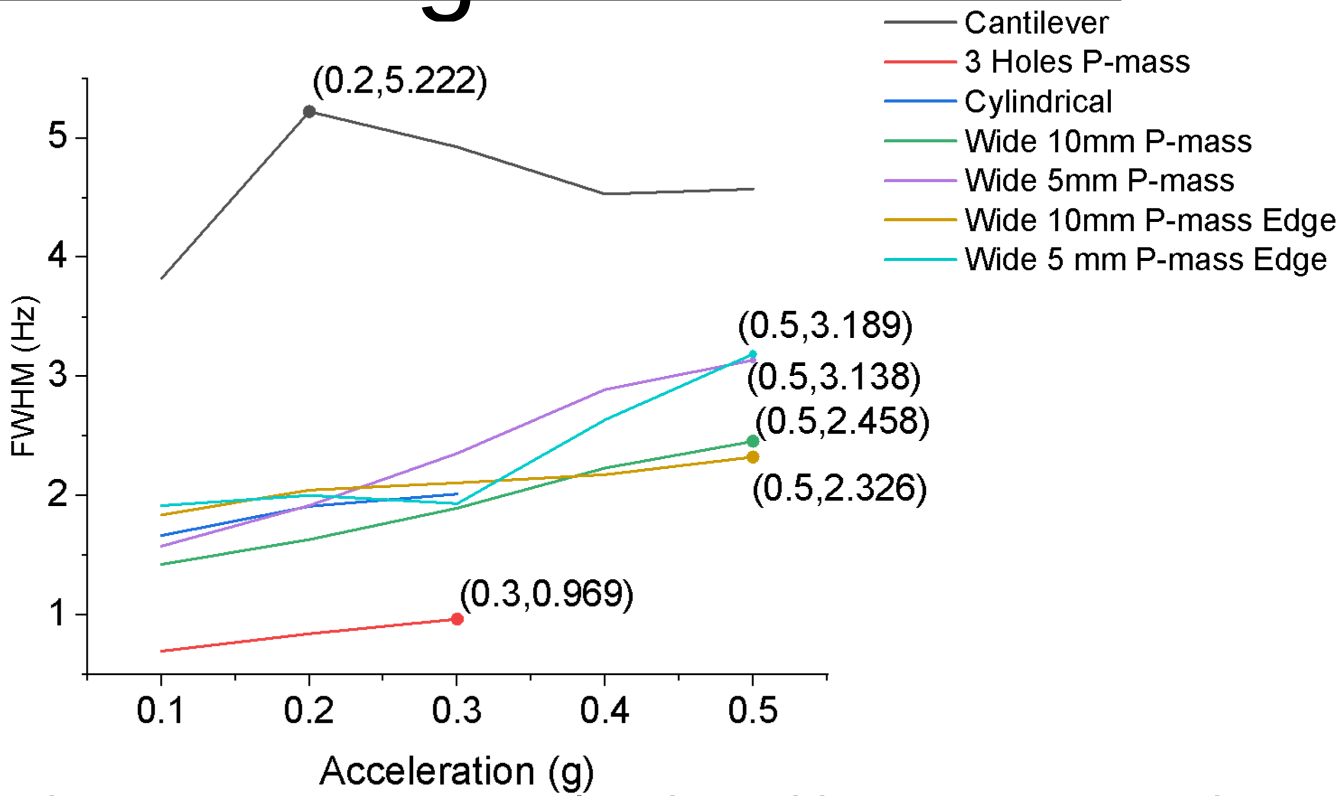


Figure 24: FWHM vs Acceleration Wide 5mm P-mass Edge P-mass

Future Works

- **Bandwidth Expansion**: We plan to continue working on increasing the bandwidth of piezoelectric devices by studying different P-mass shapes that allow expanding their working range.

- **Experimentation with 3D Printing Materials**: We aim to explore different 3D printing materials to adjust the weight of the pieces, regardless of their dimensions. This approach will allow us to modify the physical properties of the devices without changing their size.

- **Data Analysis and Testing**: We will implement a series of tests with different materials and P-mass shapes to collect and analyze data. These analyses will help us understand how these variations impact the bandwidth of piezoelectric devices.

Center for High Technology Materials

Thank You

Dr. Nathan Jackson, Director of Nanoscience and Microsystems Engineering Professor In Mechanical Engineering
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Any Question or doubts?

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References

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[2] N. Jackson and F. Stam, "Sloshing liquid-metal mass for widening the bandwidth of a vibration energy harvester," Sensors and Actuators A: Physical, vol. 284, pp. 17-21, 2018. [Online]. Available: https://doi.org/10.1016/j.sna.2018.10.010.

[3] N. Jackson, F. Stam, O. Z. Olszewski, H. Doyle, A. Quinn, and A. Mathewson, "Widening the bandwidth of vibration energy harvesters using a liquid-based non-uniform load distribution," Sensors and Actuators A: Physical, vol. 246, pp. 170-179, 2016. [Online]. Available: https://doi.org/10.1016/j.sna.2016.04.063.

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