10b piezoelectric energy harvesting devices and system
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SELFTUNING 4DOF PIEZOELECTRIC ENERGY HARVESTER WITH ENHANCED BANDWIDTH ACHIEVED BY ANALYTICAL MODEL

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In this paper we present a self-tuning piezoelectric energy harvester with enhanced bandwidth achieved by a sliding mass. The obtained enhanced bandwidth is based on analytical calculation for necessary configuration adjustments on the harvester. The concept for this 4DOF piezoelectric harvester was reported at PowerMEMS 2015 [1], where it was presented that a maintained voltage output was achieved by distributed stress over the piezoelectric cantilevers [2]. It was also presented that a sliding mass had a broader bandwidth than if the mass was fixed on the middle beam.

However the harvester in this work differs from the former by being based on an analytical model that predicts how the bandwidth becomes wider by making the harvester asymmetrical via adjusting the stiffness of the piezoelectric beams. Presented is a bandwidth comparison for symmetric and asymmetric setup, to verify the analytical prediction.

The harvester contains of a top piezoelectric cantilever (MIDE 2044), connected to a back folded middle beam via a coupling. On the middle beam, a sliding mass is placed and the other end is connected to a bottom piezoelectric cantilever via a coupling. The harvester is presented schematically in figure 1. Specifications for the couplings, mass and middle beam are in table 1.

Based on the result from the previous report [1] an analytical model was developed. The analytical model, gave a clear prediction that if an asymmetry for the harvester was created, by altering the length of the piezoelectric cantilevers, the bandwidth for the harvester would be increased. The configuration of analytical model; top/bottom; 22/22 and 23/21, where 23/21 yields a theoretical bandwidth of 60 Hz, presented in figure 2.

To validate the analytical model the harvester was measured with a symmetric setup and an asymmetric setup. In figure 3 the measurement equipment is presented. The applied frequency was 100 – 300 Hz. Before recording measurements the harvester was tested till the sliding mass was repeating its movement. While recording, the frequency was increased by 1 Hz at the time and was not changed till the mass either was stable or moved to a new position on the middle beam and become stable. The symmetry chosen is 20/20 and asymmetry 23/17. The total piezoelectric area is equal for both setups.

In figure 4 the RMS Voltage output is presented for the 20/20 and 23/17 case. As seen the 20/20 has a higher top output but the 23/17 case has a much broader bandwidth. The 3db bandwidth (RMS Voltage output) for 20/20 is 11 Hz and for 23/17 it is 21 Hz. Both 3 dB are above the critical 5.13 V, which is required to maintain power for a ZigBee (802.15.4) equipped with a sensor and transmitting continuously [3]. In figure 5 we can see that the RMS power output has the same alignment as for the voltage output due to maintained total piezoelectric area, with 0.16 W above the critical limit. The verified prediction for broader bandwidth by asymmetric setup looks very promising for future development of the harvester.

Word count: 499

References

[1] L G H Staaf, E Köhler, M Soeiro, P Lundgren and P Enoksson, “Smart design selftuning piezoelectric energy harvester intended for gas turbines” PowerMEMS Journal of Physics: Conf Series 66, 2015
[2] L.G.H Staaf, E. Köhler, D. Parthasarathy, P. Lundgren and P. Enoksson ”Simulation and experimental demonstration of improved efficiency in coupled piezoelectric cantilevers by extended strain distribution”, Sensors and actuators A-physical , 2015
[3] L. G. H. Staaf, E. Köhler, J. Kemp, M. Allen, S. Zenkic, A. Lindblom, M. Christodoulou, J. Roberts, P. Lundgren, P. “Piezoelectric energy harvesting as energy source for autonomous intelligent wireless systems on gas turbines” conf. EVI-GTI Berlin 2016

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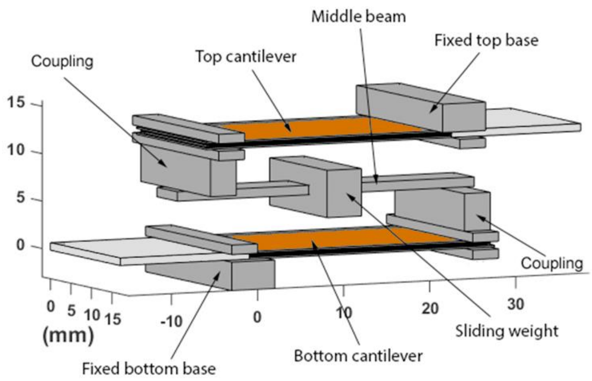

Figure 1, Schematic setup of the harvester

	Weight (g)	Thickness (mm)	Open length (mm)
Total	3.12	-	-
Coupling	1.04	-	-
Sliding mass	0.9	-	-
Middle beam	0.13	0.35	26.5

Table 1, Technical data for the aluminum parts, coupling, middle beam and sliding mass

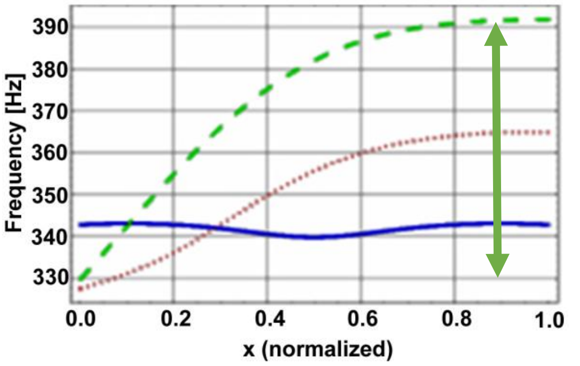

Figure 2, Eigenfrequencies for different positions x of a fixed mass. Upper/lower beam lengths are: 22/22 mm (solid blue), 23/21 mm (dotted red), 24/20 mm (dashed green). The theoretical bandwidth of 60 Hz is marked by the green arrow

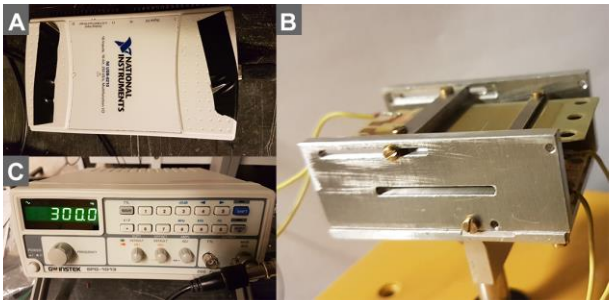

Figure 3, A) Texas Instrument USB-6210, B) The harvester on the shaker, C) Function generator SFG-1013

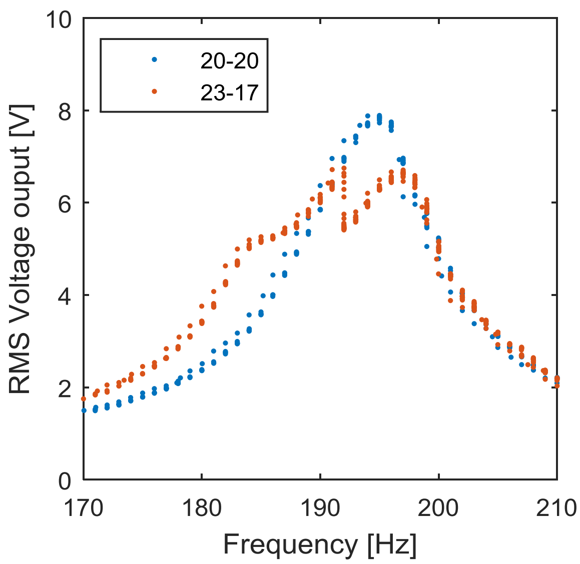

Figure 4, RMS Voltage output for symmetric 20/20 (blue) and asymmetric 23/17 (red)

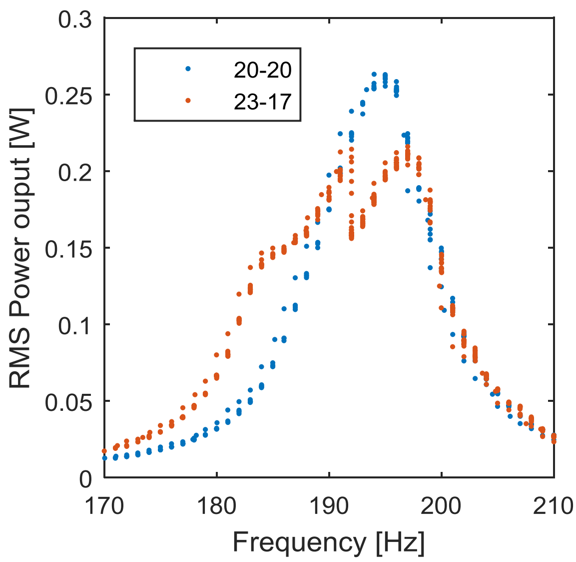

Figure 5, *RMS power output for symmetric 20/20 (blue) and asymmetric 23/17 (red)*