Kinetic energy harvesting using a piezoelectricity device. Characterization and mounting

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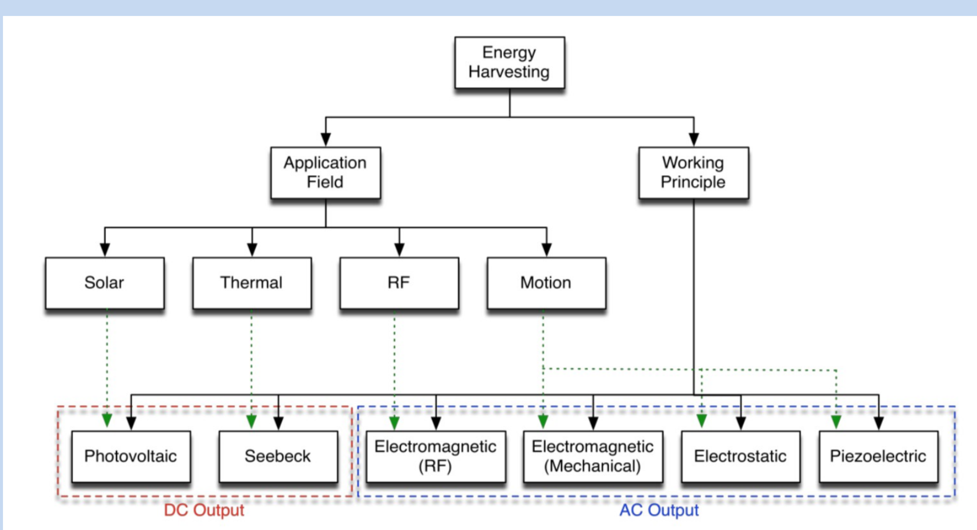
Abstract

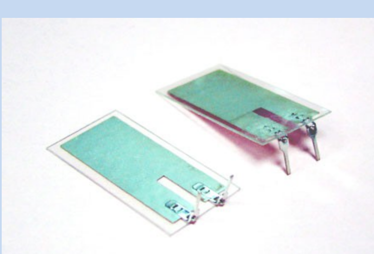
In this work, the process of environmental energy harvesting and its conversion into electrical energy has been studied. On the one hand, we have analyzed the different types of environmental energy and the physical phenomena associated to their harvesting; and on the other hand, we have proposed, as a case of study, the harvesting of kinetic energy (vibration) by a piezoelectric transducer. Based on a theoretical analysis of the piezoelectric phenomenon we have designed, simulated, implemented and analyzed a harverster system (transducer, adapter circuit, load). The piezoelectric device has been modeled and characterized, and finally, the process of the vibratory energy harversting from an air flow has been analized both in the simulation and the experimental level.

State of the art

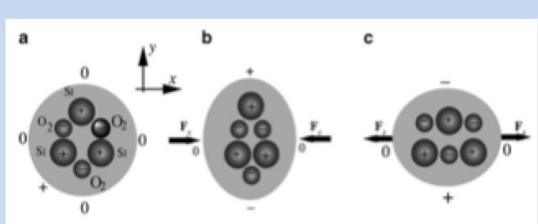
Wireless Sensor Network



Hierarchy of main energy harvesting technologies.

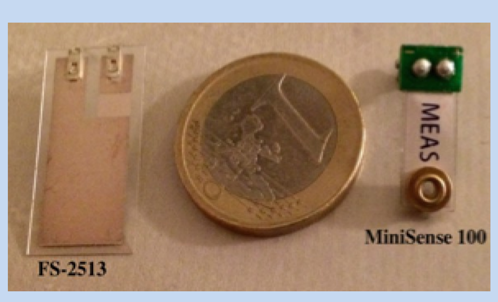


Piezoelectric devices

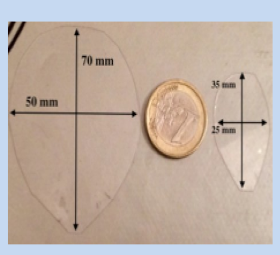


Piezoelectric effetct in Quartz by A.Meissner \I

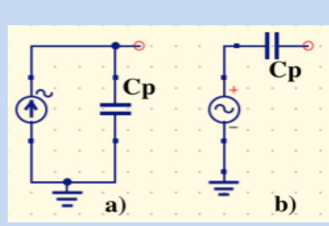
Transducer



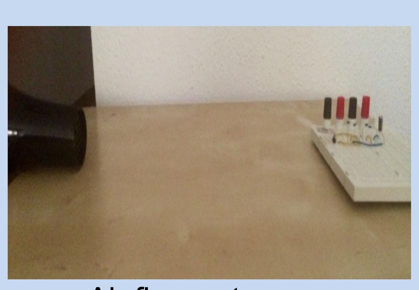
Commercial piezoelectric devices



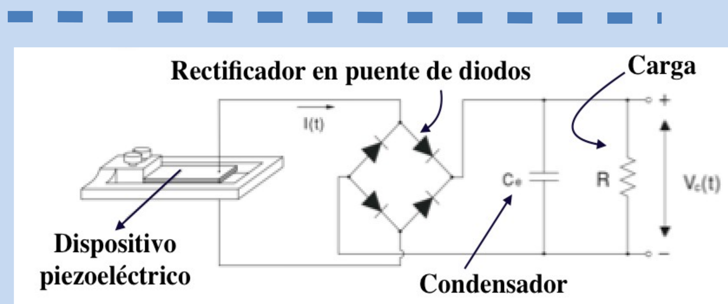
Flaps



Piezoelectric circuital model a) Norton and b)Thevenin

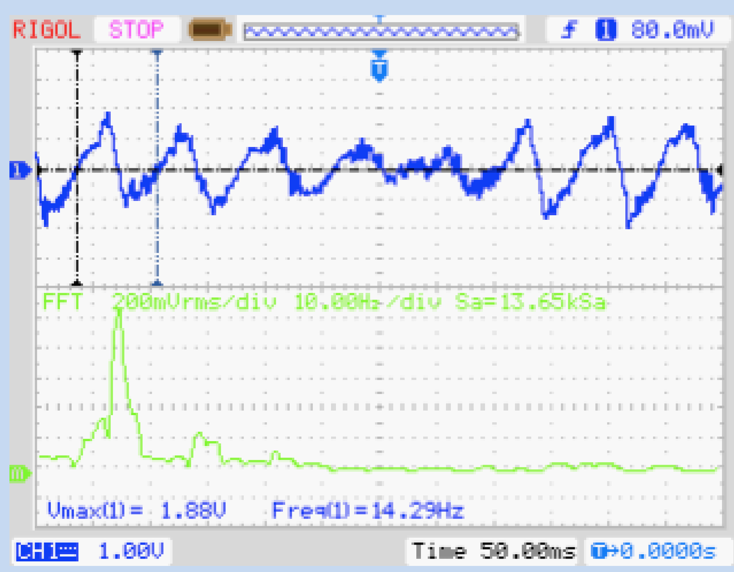


Air flow set-up



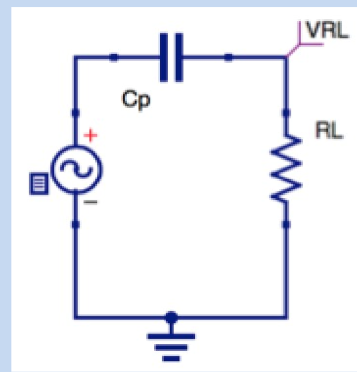
Harvester system

Experimental and simulated results

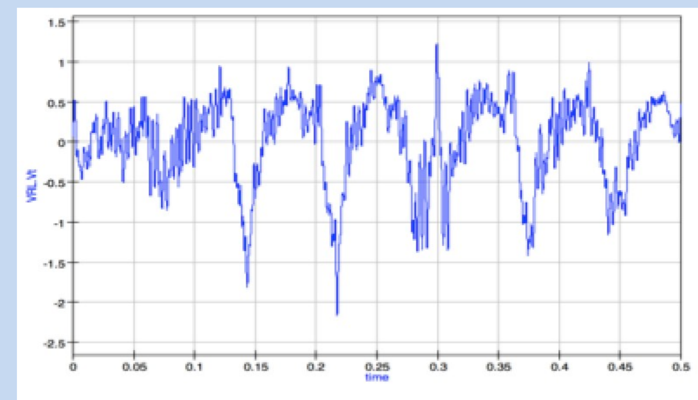


Output voltage in open circuit and Fourier Transform for the FS-2513 + Small Flap

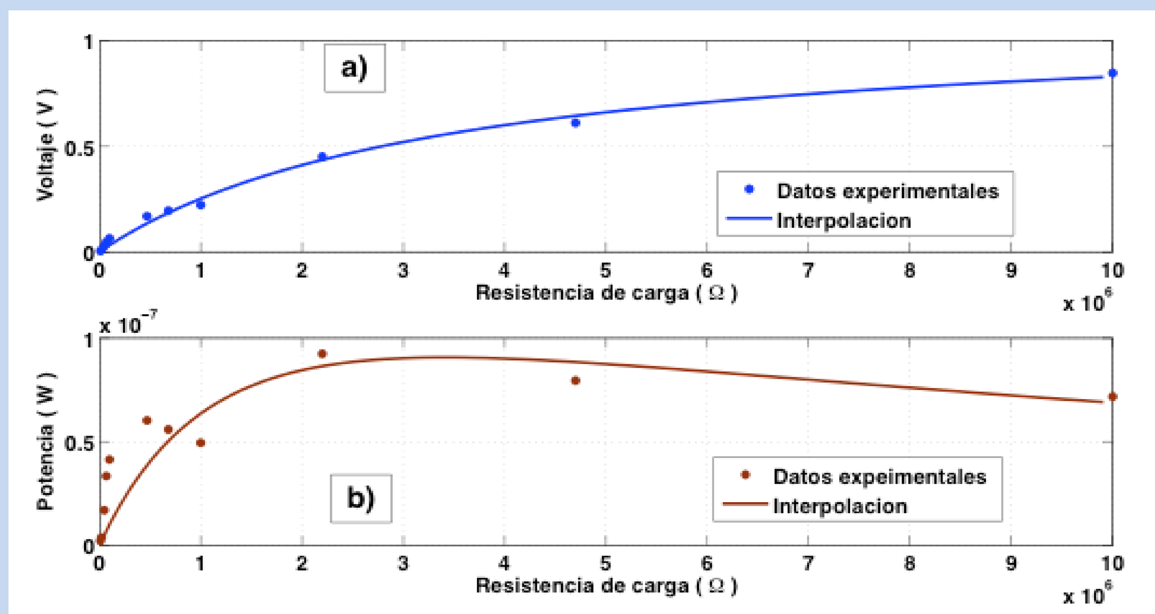
$$R_o = \frac{1}{2\,\pi\, f\, C_p}$$



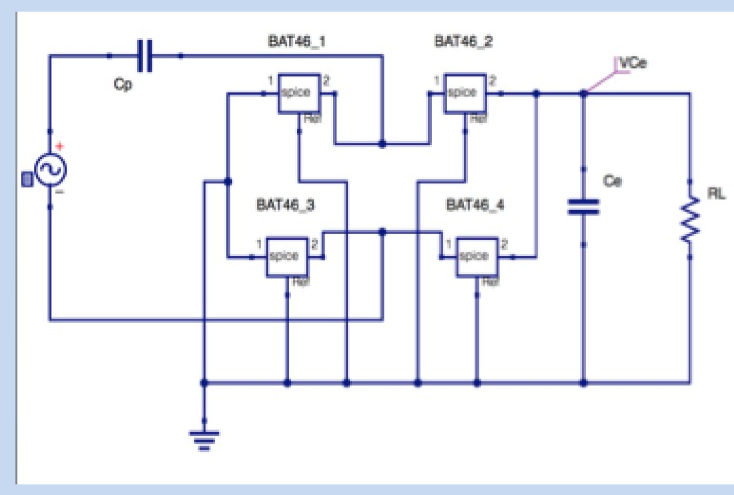
Piezoelectric device characterization



Simulated output voltage in RL=2,2 MΩ



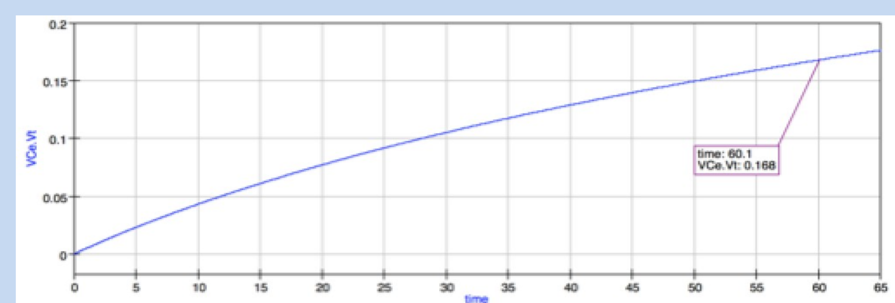
Experimental and simulated voltage and power measurements as a function of RL



Schematic model of the harvester system

Condensador (uF)	10	22	47	100	470
Tensión (mV)	380	315	286	135	30
Energía (nWh)	0.2	0.3	0.53	0.25	0.06

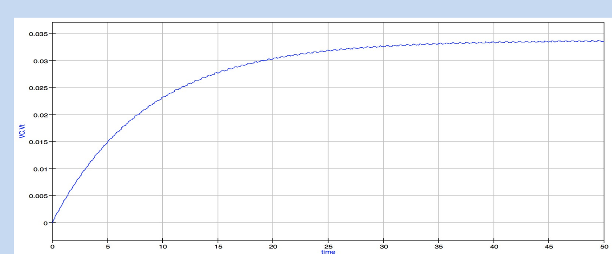
Energy stored in a capacitor during 1 minute



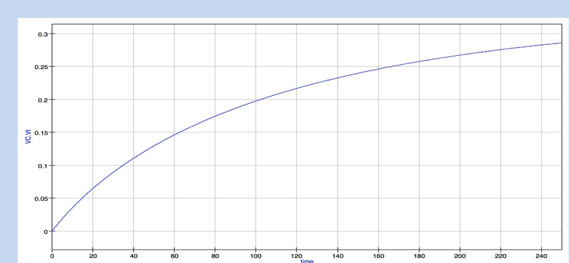
Simulated capacitor voltage in time (Ce=100uF)

R(Ω)	100 k	470k	1M	2.2M
V(mV)	30	90	160	250
I(nA)	300	200	160	113
P(nW)	9	18	25	28

Transferred power from the piezoelectric device as a function of the load



Simulated capacitor voltage with a load (100 kΩ)



Simulated capacitor voltage with a load (2.2 MΩ)

Conclusions and future work

In this work we have studied the general energy harvesting phenomenon and we have focused on kinetic energy harvesting by means of a piezoelectric device.

The piezoelectric device has been characterized, modeled and inserted in a full harvesting system.

Different experimental measurements have been carried out and simulated: Stored energy in a capacitor in one minute depending on its capacity; and transferred power from the piezoelectric device to a load.

Experimental and simulated results are very close, and powers between 9 and 30 nW had been obtained.

Future work

Studying a more complex piezoelectric harvesting system based on multiple piezoelectric devices in a series configuration.

References

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