An aeroacoustic energy harvester for supplying power to embedded sensors in aircrafts

Romain Monthéard, Marise Bafleur, Vincent Boitier, Jean-Marie Dilhac, Nicolas Nolhier, Christophe Airiau, E. Piot

An aeroacoustic energy harvester for supplying power to embedded sensors in aircrafts

Romain Monthéard, Marise Bafleur, Vincent Boitier,
Jean-Marie Dilhac, Nicolas Nolhier
CNRS, LAAS
Univ. de Toulouse, INSA, UPS
Toulouse, France
romain.montheard@laas.fr

Christophe Airiau
IMFT, Université de Toulouse
Toulouse, France
christophe.airiau@imft.fr

Estelle Piot
ONERA – the French Aerospace Lab
Toulouse-31055 Cedex, France
estelle.piot@onera.fr

***Abstract*—The present work is related to the problem of energy autonomy within sensor networks embedded onboard aircrafts. More precisely, the design and experimental testing of an aeroacoustic energy transducer associated with dedicated power management electronics are described.**

Keywords—aeroacoustic energy harvesting, power management, autonomous embedded sensors

Various ambient energy sources (solar, thermal, vibrational, etc…) have been considered for powering wireless embedded sensors. However, there are locations on an aircraft, where these energy sources may not be reliable, or not available at all. In order to provide an alternate source, energy harvesting from aeroacoustic noise has been investigated.

This technique consists in submitting a small cavity to an airflow such as that can be found outside an aircraft. It produces steady pressure oscillations, which can be converted into electricity using for instance a piezoelectric transducer. One advantage of such a technique is that power generation only relies on the aircraft speed, which can be assumed to be always present during normal operation, and represents an abundant resource.

It has been previously reported that such a transduction mechanism can be used to produce electrical power using acoustic resonators [1,2] as well as simple rectangular or cylindrical cavities [3,4], where the useful power can be in the range of milliwatts.

Here we report advances in the process of demonstrating the capabilities of aeroacoustic energy harvesting in supplying power to an autonomous wireless sensor node. A transducer based on a rectangular cavity and a piezoelectric diaphragm

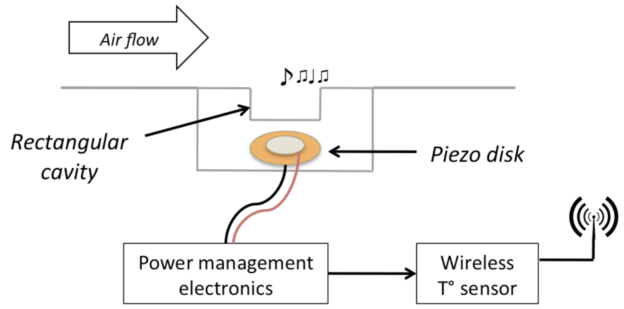

Fig. 1. Principle of the aeroacoustic energy harvester

has been fabricated (see Fig. 1) and tested under varying airflow speeds up to Mach 0.6. A sample voltage amplitude spectrum is shown on Fig. 2, where it can be seen that such a transducer is able to produce clear distinct tones, which makes it suitable for use with common piezoelectric interface circuits.

In order to improve power transfer from this transducer, a dedicated power management circuit has been designed. It consists of a self-powered SSHI converter (*Synchronized Switch Harvesting on Inductor* [4]) associated with a buck-boost converter used to perform load matching [5,6]. This circuit is shown to be able to deliver electrical power in the milliwatt range. A self-standing system capable of charging a pair of supercapacitors and supplying power to a wireless temperature sensor is demonstrated.

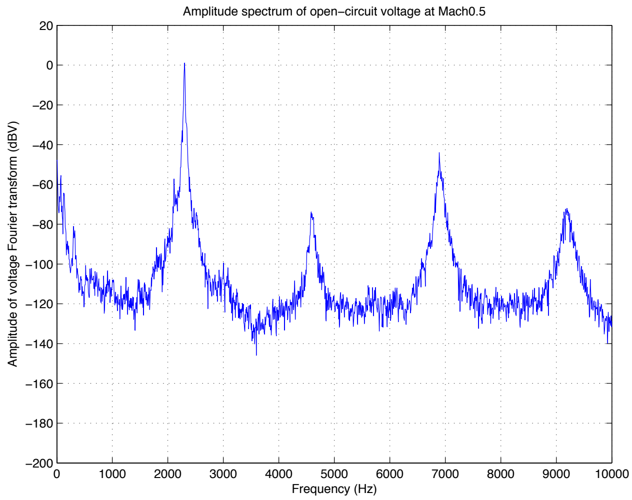

Fig. 2. Generated voltage amplitude spectrum at Mach 0.4

References

[1] S.-H. Kim, C.-H. Ji, P. Galle, F. Herrault, X. Wu, J.-H. Lee, C.-A. Choi, and M. G. Allen, "An electromagnetic energy scavenger from direct airflow," Journal of Micromechanics and Microengineering, vol. 19, no. 9, 2009.

[2] S. Matova, R. Elfrink, R. Vullers, and R. van Schaijk, "Harvesting energy from airflow with micromachined piezoelectric harvester inside a helmholtz resonator," in Proceedings of PowerMEMS 2010, (Leuven, Belgium), nov. - dec. 2010.

[3] R. Hernandez, S. Jung, and K. I. Matveev, "Acoustic energy harvesting from vortex-induced tonal sound in a baffled pipe," in Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, SAGE, June 2011.

[4] R. Monthéard, S. Carbonne, M. Bafleur, V. Boitier, J.-M. Dilhac, X. Dollat, N. Nolhier, E. Piot, and C. Airiau, "Proof of concept of energy harvesting from aero acoustic noise," in Proceedings of PowerMEMS 2012, (Atlanta, USA), dec. 2012.

[5] M. Lallart, E. Lefeuvre, C. Richard, and D. Guyomar, "Self-powered circuit for broadband, multimodal piezoelectric vibration control," Sensors and Actuators A, vol. 143, pp. 377–382, 2008.

[6] E. Lefeuvre, D. Audigier, C. Richard, and D. Guyomar, "Buck-boost converter for sensorless power optimization of piezoelectric energy harvester," IEEE Transactions on Power Electronics, vol. 22, pp. 2018–2025, sept. 2007.

[7] N. Kong, D. S. Ha, A. Erturk, and D. J. Inman, "Resistive impedance matching circuit for piezoelectric energy harvesting," Journal of Intelligent Materials Systems and Structures, vol. 21, September 2010.