Metrology for energy harvesting
European Metrology Research Programme

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Project news

Dr Mauro Zucca and colleagues at **INRIM** in Italy have had their paper titled "Hysteretic modelling of electrical micro-power generators based on Villari effect" accepted by the IEEE transactions on magnetics journal. It will be published in November.

This paper proposes the validation of a modelling approach to evaluate the performance of a vibration harvester based on bulk magnetostrictive (MS) materials. The work was carried out through a simulation tool and represents an improvement of the work described in newsletter five of the project.

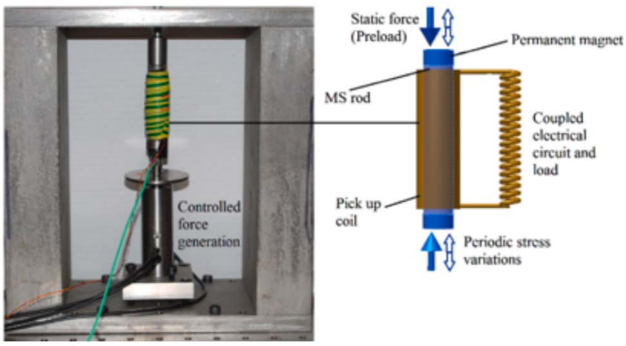

Figure 1. Generator scheme. A rod of MS material is inserted in a pickup coil, this latter connected to an electric impedance. Two permanent magnets provide the magnetic bias. The material is preloaded with a constant stress, while a time varying mechanical load is exerted longitudinally along the rod axis.

Of particular interest is the translation of the model into a finite element code and the realisation of an experimental set-up for the validation of the results. Highlights include the mathematical law, derived experimentally, between power output and stress applied to the material and the electrical power delivered versus the electrical current.

In September Dr Mauro Zucca and colleagues from **INRIM** helped organise a seminar in Torino titled "Energy Harvesting Using Magnetostrictive Materials" which presented some of the work recently carried out by an Italian-Egyptian research project, led by Professor Amr A. Adly, from Cairo University. Around 20 academics from across Europe attended the event.

Researchers at **Physikalisch-Technische Bundesanstalt** have had two papers accepted by leading journals. '"Traceable measurements of electrical conductivity and Seebeck coefficient of β-Fe0.95Co0.05Si2 and Ge in the temperature range from 300 K to 850 K" will be published in the upcoming issue of Physica Satus Solidi.

A second paper "Traceable Thermoelectric Measurements of Seebeck Coefficients in the Temperature Range from 300 K to 900 K" will be published in the International Journal of Thermophysics.

The paper presented by Rado Lapuh and colleagues from the **Slovenski institut za kakovost in meroslovje** at the *Conference on Precision Electromagnetic Measurements (CPEM)* is now available online *here* (behind a paywall). A copy of the paper is available from *Rado* to any list member free upon request.

The paper describes the development of a digital arbitrary waveform generator used for the simulation of energy harvesters. It is able to generate arbitrary signals that are common for different energy harvesters, including piezoelectric, thermoelectric and mechanical devices.

***Visit our homepage at** http://projects.npl.co.uk/energy_harvesting*

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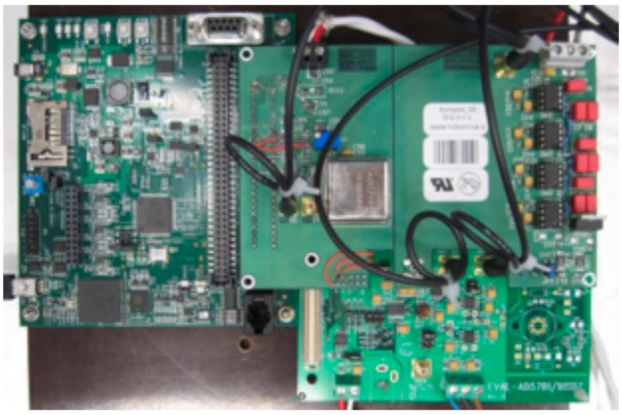

Figure. 2. PCB view of the prototype arbitrary waveform generator. DAC manufacturer demo board was used for the current prototype.

The next step is to verify the accuracy of the signal and then the accuracy of the measurement equipment measuring it. Then finally this standardised metrology set up can be used to calibrate equipment of all the measurement institutes around Europe, starting with PTB in Germany and INRIM in Italy.

A new ***project website*** has been created where it is now possible to download past issues of the energy harvesting newsletter. Content from the Metrology for Energy Harvesting blog will also be transferred over to the site over the coming months. Please note that the old blog address is no longer functional.

Figure 3. New project homepage

Upcoming events

IDTechEx Energy Harvesting & Storage USA 2012

7th November 2012 - 8th November 2012
Washington, DC

Electronica 2012

13th – 16th November
New Munich Trade Fair, Germany

IEEE MEMS 2013

20th – 24th January 2013
Taipei, Taiwan

Piezo 2013

17th – 20th March 2013
France

SPIE Microtechnologies

24th – 26th April 2013
Grenoble, France

View from industry:

Gerold Schröpfer, Director, European Operations and Foundry Partner Program, Coventor

What does Coventor do?

Coventor develops and supplies software tools that can be used for the design of micro electromechanical systems (MEMS) and the modelling of semiconductor and MEMS manufacturing processes. The modelling of MEMS energy harvesters is a small but growing area of our business.

Our products enable the co-design and co-simulation of a harvesting device and a conditioning circuit together. It allows users to play around with the both the harvester design parameters and circuit parameters in order to optimise device performance before committing to time-consuming and costly build-and-test cycles. The design can also be checked for high stress areas that may lead to breakage when the device is overloaded.

What is your role?

I work in Paris at Coventor's European HQ where I'm in charge of the European operations, mainly the research and development centre. I also run a partner program with the worldwide MEMS Foundries, an open facility where design houses without manufacturing capabilities can go and turn their design into actual products

Where do your customers come from?

Coventor has a well-recognized leading position for MEMS design software. In the MEMS industry, 11 of the top 15 suppliers use Coventor's tools. 5-6 years ago, our customer base interested in energy harvesters was purely academic. More recently, we are seeing more and more industrial companies interested in this technology, particularly piezo-energy harvesting.

The majority of industrial interest is focused on the need to power wireless sensor nodes and this would seem to be the main driver of growth in the sector. HP and BOSCH have published vision statements declaring that in the future there will be billions of sensors deployed around the world and these will all need low cost power, preferably from a wireless source to remove complex cabling.

Another industrial interest for MEMS-based energy harvesters is in medical applications, particularly using them for implantable devices where it is difficult to substitute batteries. In the consumer world we have seen preliminary research into the use of energy harvesting devices in sporting shoes for health monitoring whilst aerospace is another area of industrial research interest.

How long have you been interested in energy harvesting?

While MEMS have been investigated for many years in relation to energy harvesting, my personal interest in this area began around 2007, during that year's Transducers Conference where we saw several presentations on the use of MEMS for energy harvesting. Since then I have followed the sector's progress and seen the increasing academic interest this generated and how that is starting to spill over into the commercial world.

What were your initial thoughts?

The first information we had was presentations from universities. The thing I found particularly exciting was the idea you could use existing technology and transducers and apply it to a completely new area, giving you the potential to provide continuous power to small systems. This made the technology of energy harvesting very promising.

What do you feel will be the main areas to benefits from energy harvesting technologies?

Wireless sensor networks will be of particular interest for controlling environmental health and habitation issues where it is difficult or even impossible to replace batteries. I think more and more will be employed, especially as the commercial world is starting to look beyond the upfront costs of these systems and realise the potential long terms savings and operational benefits. This could be a huge market for both sensors and the energy harvesters required to power them.

Among the family of harvesters available, the piezoelectric vibratory energy harvester is one of the most promising technologies and has more immediate applications due to the power level generated and the ease of integration with the surrounding system.

What is the relevance of metrology for energy harvesting to your company?

Metrology is extremely important for us as a software design company because all material parameters in the models we use for our software have to be well characterised. The designers might play around with geometric details of the devices or the systems but the properties of the materials and manufacturing processes used have to be known in order to make the models fully predictive.

Unfortunately you cannot just take the material properties out of the literature as the materials used are often customer made.

As a company we are constantly trying to reduce assumptions in the software tools we produce. As a result metrology and design tools go hand in hand. To put it simply the more accurate these measurements, the more reliable the models we can produce.

What do you see as the main challenges for EH devices?

One main issue is that the power is usually small as it scales with mass. And MEMS are small devices with a low mass.

Another main challenge comes from what you do once your device has generated the necessary energy. At that point you also need a good system to efficiently transfer the energy you harvest.

We must remember that harvesters are never used in isolation and you must optimise the overall system in which they operate. However for a long time there was no design platform that allowed you to design the energy harvesters along with the electric system that would surround it.

One of our more recent developments has been the incorporation of tools that not only design the component, but can connect it to other components in the system, providing a complete level of design. This was incorporated within the latest software platform called MEMS+.

Have you conducted any research into energy harvesting yourself?

At present we are working with the Norwegian research institute SINTEF and other partners in the FP7 project PIEZOVOLUME on a new material for piezo-electric MEMS, PZT, which I think will be very useful for energy harvesters. In another FP7 project, called SMAC, lead by ST Microelectronics, we investigate how to improve the overall heterogeneous system design approach of miniaturized smart systems, for which energy harvesters are one element to consider.

Where do you feel that European capability ranks in terms of developing innovative EH products?

In terms of academia, Europe pioneered this research and still today maintains a leading position from a fundamental research point of view. From a commercial viewpoint, it is more difficult. There are certainly lots of companies from the US and Asia who are interested and investing a lot of money in this technology.

Are there any areas within the metrology of energy harvesting that you would like to see further research?

From our point of view, a general focus on material and process characterisation is required. It's not fundamental research but if somebody today would like to design a MEMs harvester it is very difficult to give them access to reliable and well characterized manufacturing processes. Once these processes are established, we can develop the suitable design kits to access the technology.

We welcome feedback, opinion and suggested articles. Please send your comments to *paul.weaver@npl.co.uk* ***and*** *james@proofcommunication.com*

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