Mini generators make energy from random ambient vibrations

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Miniature generators developed at U-M's Engineering Research Center for Wireless Integrated Microsystems run on the random vibrations all around us. Credit: Tzeno Galchev

Tiny generators developed at the University of Michigan could produce enough electricity from random, ambient vibrations to power a wristwatch, pacemaker or wireless sensor.

The energy-harvesting devices, created at U-M's Engineering Research Center for Wireless Integrated Microsystems, are highly efficient at providing renewable electrical power from arbitrary, non-periodic vibrations. This type of vibration is a byproduct of traffic driving on bridges, machinery operating in factories and humans moving their limbs, for example.

The Parametric Frequency Increased Generators (PFIGs) were created by Khalil Najafi, chair of electrical and computer engineering, and Tzeno Galchev, a doctoral student in the same department.

Most similar devices have more limited abilities because they rely on regular, predictable energy sources, said Najafi, who is the Schlumberger Professor of Engineering and also a professor in the Department of Biomedical Engineering.

"The vast majority of environmental kinetic energy surrounding us everyday does not occur in periodic, repeatable patterns. Energy from traffic on a busy street or bridge or in a tunnel, and people walking up and down stairs, for example, cause vibrations that are non-periodic and occur at low frequencies," Najafi said. "Our parametric generators are more efficient in these environments."

The researchers have built three prototypes and a fourth is forthcoming. In two of the generators, the energy conversion is performed through electromagnetic induction, in which a coil is subjected to a varying magnetic field. This is a process similar to how large-scale generators in big power plants operate.

The latest and smallest device, which measures one cubic centimeter, uses a piezoelectric material, which is a type of material that produces charge when it is stressed. This version has applications in infrastructure health monitoring. The generators could one day power bridge sensors that would warn inspectors of cracks or corrosion before human eyes could discern problems.

The generators have demonstrated that they can produce up to 0.5 milliwatts (or 500 microwatts) from typical vibration amplitudes found on the human body. That's more than enough energy to run a wristwatch, which needs between one and 10 microwatts, or a pacemaker, which needs between 10 and 50. A milliwatt is 1,000 microwatts.

"The ultimate goal is to enable various applications like remote wireless sensors and surgically implanted medical devices," Galchev said. "These are long lifetime applications where it is very costly to replace depleted batteries or, worse, to have to wire the sensors to a power source."

Batteries are often an inefficient way to power the growing array of wireless sensors being created today, Najafi said. Energy scavenging can provide a better option.

"There is a fundamental question that needs to be answered about how to power wireless electronic devices, which are becoming ubiquitous and at the same time very efficient," Najafi said. "There is plenty of energy surrounding these systems in the form of vibrations, heat, solar, and wind."

These generators could also power wireless sensors deployed in buildings to make them more energy efficient, or throughout large public spaces to monitor for toxins or pollutants.

Provided by University of Michigan

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