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MECHANICAL ENERGY HARVESTING

The technology of Energy Harvesting uses ambient energy like movement, heat or light to generate electrical energy. Besides solar and thermal harvesting, mechanical harvesting using movements and vibrations is a very promising method to provide electricity with some unique advantages. Mechanical generators are employed to convert movements into electrical voltages for powering electrical devices or charging batteries.

Technologies

Mechanical energy could be used with different kinds of energy transducers to provide electric power. One option are piezoelectric materials, which exhibit a charge separation when put under mechanical stress due to a movement or a periodic vibration. Piezoelectric generators produce typically large voltages in the range of tens or even hundreds of volts, but at very low currents. They can be built as a resonating cantilever structure or applied directly on a surface which shows mechanical strain.
The cantilever structure has a resonant frequency which has to match with the exciting frequency from the environment. That makes this concept difficult for applications with non-constant vibration frequencies. Tuneable vibration harvesters can be matched to the exciting frequencies, but are much more complex.
Examples for piezoelectric materials are PZT (Lead-Zirconate-Titanate) or PVDF (Polyvinylidene fluoride). PZT is very brittle, but produces very high voltages. PVDF is very flexible, but has a lower voltage output.
Another option are electro-dynamic or inductive generators, where a combination of a magnet and a coil are the key elements for generating power. If the whole combination is exposed to a vibration, one element moves relative to the other and induces an electrical current in the coil. This current can be used after rectification to charge a battery or a capacitor.

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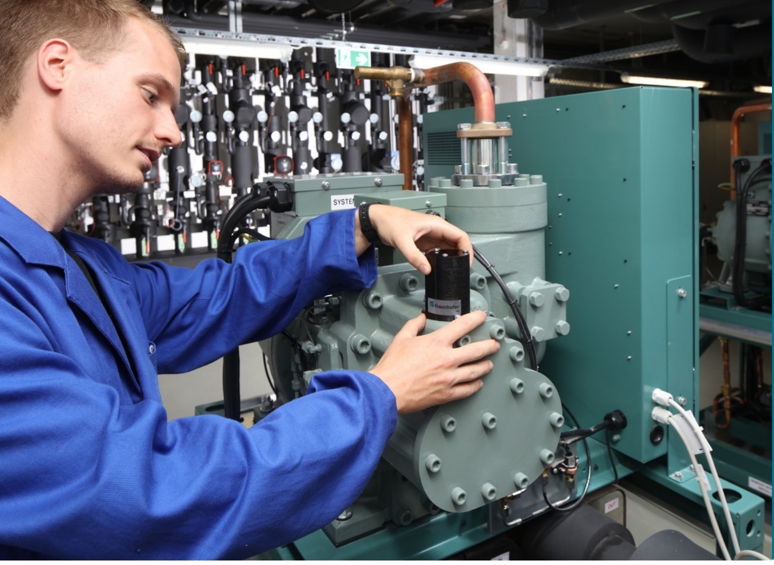

A further option is an electro-static generator. They can be compared with an electric capacitor which has one capacitor plate that can be moved relative to the other. By charging this capacitor when the plates are near to each other and discharging the capacitor when the plates are far from each other, electric power can be generated. In this principle, the output power depends on the capacitor value and its charge voltage. The critical component apart from the generator itself is the power management, which has the task to adapt the voltage or current profile from the harvester to charge a capacitor or a battery. Typically, rectifiers and DC-DC converters are used.

Applications

Typical application fields for mechanical harvesting are motors and machines, vehicles or any kinds of objects which are moving. Most often, wireless sensors or sensor networks are powered by mechanical generators. The task of these wireless sensors is always the acquisition of physical parameters in complex systems to enable a monitoring and control functionality. In more advanced applications even tracking or cellular communication systems are powered by Energy Harvesting. Typical examples are the vibrations of a motor, which can be used to power monitoring sensors. Other examples are vibrations at vehicles like trucks or railway trains to power condition monitoring systems or tracking systems. Application-specific installations use the movement of fluids or even air to excite an Energy Harvesting generator to measure the flow or the quality of a certain medium like water or oil. At the human body, the movement of arms or legs or even muscles can be used to generate energy for powering a watch, a medical sensors or textile integrated electronics.

Challenges

The realization of an efficient mechanical Energy Harvesting system faces different challenges. At first, good mechanical coupling from the vibration source to the harvester has to be provided. Mechanical simulations consider the properties and dimensions of the building blocks and calculate the optimum configuration for the proper coupling. Furthermore, a good electrical matching between the mechanical harvester and the electronic power management has to be provided. Optimized voltage regulators are used for this purpose, which might also use maximum power point tracking techniques when sufficient power is available. Finally, a highly efficient charge regulator has to be designed for application-specific energy storage devices. Considering the challenges above, a multidisciplinary approach including material science, physics and electrical engineering is mandatory to achieve a power-efficient and cost-efficient energy supply.

Our Unique Selling Propositions

– Generating electrical energy from smallest amplitudes or frequencies of vibrations or mechanical movement
– Processing lowest currents or voltages to power state-of-the-art applications or charge storage devices
– Employment of cheap materials and highly integrated electronics to arrive at competitive power supplies

Services from Fraunhofer IIS

We carry out research and development in different areas of mechanical harvesting.

We offer:

– Highly-efficient voltage converters: Maximum voltage range and high efficiency
– Charge regulators and battery management circuits: Efficient charging of different kinds of energy storage devices with optional state-of charge estimation
– Maximum Power Point Tracker Control loops for voltage converters to carry out automatic impedance matching
– Characterization of mechanical harvesters: Lab equipment for generating defined vibrations and measuring the output power as a function of various parameters
– Mechanical modelling and simulation: Software tools for modelling mechanical generators and interface structures and materials