Mechanical energy harvesting : how to design efficient piezoelectric generators

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Since the early 2000's, many new applications related to nomad electronics need "portable" electrical energy. Huge research efforts on Lithium (Li) based batteries have led to performances that made this technology the most popular for rechargeable batteries with the best energy densities. Little by little, Li batteries are replacing the conventional batteries; they are thinner, safer and more reliable. These batteries are usually plugged and recharged through a standard AC/DC converter. Recharging them thanks to renewable energy systems, such as a photovoltaic cells or thermoelectric devices, has become a major challenge for electronic industry[1]. In some specific applications, like health monitoring, medical implants, smart clothes, autonomous sensors, etc... the later sources of energy are not directly available. In such cases, an alternative source of energy to charge the Li battery is necessary. The mechanical ambient energy trough low frequency "vibrations", as for example human motion, liquid flow or engine vibrations, is a source of interest.

Energy generation utilizing piezoelectric materials has been well-studied over the past two decades[2-4]. When subjected to a mechanical force, these materials become electrically polarized. Thus, they are able to convert unused mechanical energy of our surroundings into electrical energy. Ambient mechanical sources are encountered on vehicles, industrial machines, traffic ways (roads, bridges, tunnels), passage ways, wind turbines, pipelines... or on human beings (during walk or hand movements). In order to estimate the interest to harvest such "free" energy, some important questions must be asked, in particular on the frequency range and the amplitude of the mechanical excitation, its truly free nature, its continuous or intermittent availability, the proximity of the electrical network, the interest of wireless electronic devices...

In this lecture, we will examine the key aspects of mechanical energy harvesting using piezoelectric materials, from the material choice to the design and manufacturing of the full device, including the dedicated electronics, that is usually interfacing the piezoelectric generator and the targeted electrical load. Some possible figures of merit will be presented, and the perspectives of standardization will also be discussed, illustrated with case study examples.

References

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