Piezoelectric energy harvesting – technologies and applications

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ABSTRACT

Energy harvesting, know also as energy scavenging, covers a great body of technologies and devices that transform low grade energy sources such as solar energy, environmental vibrations, thermal energy, human motion into usable electrical energy. Due to the rapid development of ultra low power electronic devices, the energy harvesting technology has become a very attractive solution for a wide variety of applications such as consumer electronics, outpatient medical electronics (hearing aids, pacemakers, smart implants) or imaging (camera inside the human body). A wireless and battery less network of remote sensors located in places where human intervention for replacement of batteries is difficult will be another very attractive application area.

Many different working principles of energy harvesting devices have been introduced so far. For example: piezoelectric, electromagnetic, electrostatic, pyroelectric, photovoltaic, thermoelectric, to name a few. The energy harvesting from environmental vibrations seems one of the most promising areas of application and the piezoelectric based conversion of energy seems one of the best solutions due to very good scalability, good miniaturisation capabilities, compatibility with the standard microelectronic technology and high energy density.

In this paper a review of the state-of-the-art for energy harvesting devices will be presented with an emphasis on piezoelectric devices. The selected models and solutions will be introduced. Moreover the basic problems concerning piezoelectric based energy harvesting from environmental vibrations (e.g. frequency matching, optimal load matching, broadband harvesting) will be discussed. A general comparison of the existing solutions will be presented based on the proposed figures of merit.

It must be pointed out that the development of the final working devices employing energy harvesting technique requires a new design approach that exploits all of the available features of the particular application implying that the particular solution should be always tailored to the application. This creates new challenges both for the material as well as the device developers and manufacturers.