Grand Challenge Research on Energy Harvesting – From Components to System Integration

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The rapid advancement of CMOS low power circuitry and the upsurge in wireless sensor applications enabled lots for new application filed of wireless sensor network. However, how to extend the battery lifetime of the sensor nodes and is therefore a major issue and attracted many researchers' interest in developing possible solutions. Energy Harvesting technologies to collect energy from the ambient environments to drive electronics circuits independent from the main power or from a battery, may in fact prove critical to the proliferation of these technologies. Energy harvesting not only reduces the maintenance effort by ridding the batteries, it also provides an effective answer to an ever growing awareness for the need for green appliances. Energy from the environment is plentiful, including solar light, thermal gradient, vibration or motion is generally mentioned as possible energy sources. Vibration or mechanical movement is already used widely in a well known consumer application. Wrist-watches that do not need a battery are already a commercialized matured product. Mechanical vibration energy can be converted into usable electrical energy through piezoelectric, electromagnetic and electrostatic transducers. The piezoelectric transducer is considered a potential choice when compared with electromagnetic and electrostatic transducers due to its high energy density. Furthermore, piezoelectric material that has been found to have the ability to convert vibration energy into electric power has sparked much attention as it was attractive for use in MEMS applications.

The research and development of energy harvesting technologies, from components to system integration, is facing many challenges. In addition to identify the energy sources, efficiently converting different energy sources into useful electricity, a short term or long-term efficiently energy storage device, optimized interfacing circuit for maximized conversion efficiency and power management schemes combining difference energy sources are all challenges for integrating practical field solutions. To improve the converting efficiency of the energy transducers, an optimal transducer design and new or improved functional materials of various generators that adopting piezoelectric, electromagnetic or electrostatic mechanism is important in energy conversion stage. An urgent power management scheme, an optimized interfacing circuit to maximize the power output and a buffer stage for energy storage is usually required in practical applications. Furthermore, more in-depth studies are needed for the transient dynamics of the power harvesting system, since there is a wide range of applications that do not operate at steady state. To realize the integration and to maximize the amount of harvested energy involves several factors, including electronics optimization, characterization of the available ambient energy, selection and configuration of energy harvesting materials, and integration with storage mechanisms. For integrating appropriate functionalities within the wireless sensor devices with energy harvesting system, these issues in an integrated manner need the multidisciplinary engineering perspective.