Energy Harvesting - from Devices to Systems

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Abstract

Energy harvesting (also known as power harvesting or energy scavenging) is the process by which energy is derived from external sources (e.g., solar power, thermal energy, wind energy, salinity gradients, and kinetic energy), captured, and stored. Frequently, this term is applied when speaking about small, wireless autonomous devices, like those used in wearable electronics and wireless sensor networks. (http://www.wikipedia.org)

The talk covers both the transducer concepts and devices used to convert ambient energy into electrical power and also the circuits required to drive these components at the right operating point to achieve a high efficiency.

The introduction explores the applications and systems where energy harvesting can be applied to power autonomous devices with functions such as readout of remote sensors, observation of the environment, surveillance of buildings and industrial plants.

Some systems convert kinetic energy from motions and vibrations by using piezoelectric, electrostatic and electromagnetic concepts. The result is an AC output power. Electrostatic or capacitive harvesting is based on the effect that vibrations separate the plates of a variable capacitor, thus converting mechanical into electrical energy. Mechanical strain on piezoelectric devices can generate electrical current or voltage and vibrating magnets moving past a coil can be used to gather electrical power.

Other concepts use electrochemical, photovoltaic or thermoelectric concepts to provide a DC energy source using fuel cells, light radiation or heat gradients. Thermoelectric generators, for example, are built up as a junction of two different materials. By connecting many devices in series a usable voltage can be achieved at the presence of thermal gradients.

These power sources deliver low levels of usable energy, thus any system will have to seek ways to maximize the effectiveness. So diverse the energy sources are, even more wide ranging are the transduction principles that can be applied to convert the available energy to electrical power. Each one of these schemes will require a different circuit technique for achieving an optimal conversion. This adaptive control has to be intelligent enough to always find the optimum without itself requiring too large amounts of energy. Here lies a major challenge for low-power and low voltage electronics.