Energy Harvesting Enables Ultra-Low Power Applications

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There are a variety of systems and applications that could benefit from energy harvesting (EH). Energy harvesting refers to the technology by which ambient sources of energy such as light, thermal gradient, and vibration can be harvested and stored then applied later for doing useful work. Examples of systems that could benefit from EH include wireless sensor networks (WSNs), smoke alarms, wireless keyboards and mice. Each application is untethered to the power grid and requires local energy storage, such as batteries. EH enables a longer run time, reduces maintenance and in some cases, eliminates a battery altogether. This article explores a few applications where EH can be an enhancement.

As the name implies, WSNs are a network of sensors that communicate wirelessly and are self-powered. An example of a WSN is a collection of sensors that monitor a bridge's structural integrity. The network can be distributed over a large area covering several square kilometers. The infrastructure to provide wired communication with the sensors and power distribution does not exist. It would be costly and impractical to provide this infrastructure. However, using energy harvesters allows each sensor node to be self-powered.

There are two types of energy harvesters that could be used for this application – solar panels and/or vibration harvesters. Solar panels could harvest energy from the sunlight whereas a vibration-based harvester could harvest energy from the vibrations on the bridge created by moving vehicles. A WSN powered from a primary battery requires periodic maintenance. For example, replacing thousands of batteries on a bridge would be a very costly (and dangerous) endeavor. Energy harvesting, in conjunction with a rechargeable battery or capacitor, could realize a perpetually-powered system. For a system that uses a primary battery, energy harvesting could extend the system's run time and reduce maintenance costs.

Figure 1 is a typical system diagram of a WSN, which consists of five major components: the energy harvester, the energy storage element and power management circuitry, sensor, ultra-low power microcontroller, and low-power transceiver. The energy storage element is required in order to accumulate the energy for usage when the energy harvester is not harvesting energy, for example a solar panel system during the night. The energy storage element must be rechargeable. The power management is critical as it interfaces to the harvester, charges the storage element, and provides power to the system. Sensor data is recorded and processed by the microcontroller. Finally, the data is transmitted to a central host by the transceiver.

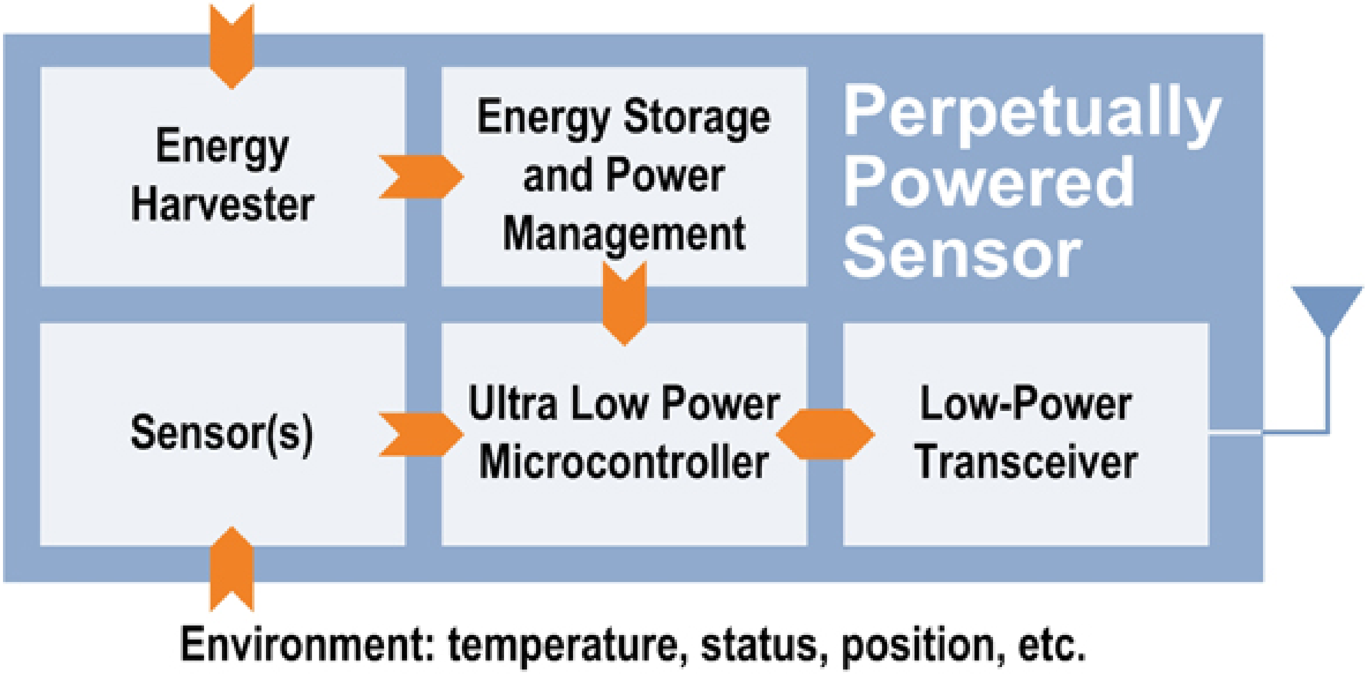

Figure 1. Anatomy of a wireless sensor network incorporating an energy harvester.

Smoke and carbon monoxide detectors also can benefit from EH. Currently, most of these devices are powered by primary batteries. Replacing these batteries is labor intensive and a huge annoyance because usually they are located in difficult to reach areas and are problematic to change at night. What often happens is that the detector is left disabled – which creates a safety hazard!

Consumers definitely will benefit from the advantages that EH will bring to these detectors. Solar panels are a suitable source of energy to power a smoke detector. Smoke detectors use systems similar to WSNs, except that they don't need a transceiver, and an audible alert is required. By incorporating EH, a more intelligent power management architecture is required so that maximum energy is extracted from the solar panel and charging and managing the rechargeable storage element is provided. The rest of the system can remain the same.

Another example of enabling an ultra-low power application with EH is for computer mice and keyboards where wireless communication and power from computer keyboards and mice is highly desirable. This allows for a cleaner, more organized desktop with flexibility in movement and placement of the components. Because the keyboard and mouse are untethered, they require a local source of power and wireless communication. This is very similar to the requirements found in a WSN.

As in our previous examples, battery replacement is an annoyance and adds cost to the lifetime usage of the product, and is not a green solution. Most computer equipment is operated in a home or office environment where ample light is available. This light can be harvested for usage with a solar panel integrated into the keyboard and mouse. Motion also occurs with both the keyboard and mouse. Harvesters can extract energy from this motion to power both devices.

In each of these applications, an integrated circuit (IC) that can extract the energy from the harvester and manage the storage element is required. The BQ25504, a boost charger IC, can be used in these systems. It has a unique interface which maximizes the energy from solar or thermoelectric harvesters. This allows the system designer to use a smaller (cheaper) harvester since more energy is available for a given area or volume. It also has an industry leading quiescent current of 330 nA that enables longer application run time.