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APPLICATION NOTE 5259

Energy Harvesting Systems Power the Powerless

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Abstract: Energy harvesting (also known as power harvesting or energy scavenging) allows electronics to operate where there is no conventional power source, thus eliminating the need for wires or replacement batteries. This article describes several unconventional energy sources that can be used to power circuitry, and outlines applications for the process. It also explains design challenges that must be addressed to implement a fully functional energy harvesting solution.

A similar version of this article appeared in the January 2012 issue of *Bodo's Power Systems*.

Introduction

Modern electronic systems solve so many difficult problems that they often seem like magic. Nonetheless, these systems all have the same basic limitation: they need a source of electrical power! Most of the time this is a straightforward challenge for the electronic designer, because there are many power-delivery solutions. Yet sometimes a device has no direct power source, and running wires or replacing batteries is impractical. Even when long-life batteries are usable, they eventually need to be replaced, which requires a service call.

Enter energy harvesting. Energy harvesting (also known as power harvesting or energy scavenging) allows electronics to operate where there is no conventional power source. It eliminates the need for wires or replacement batteries.

This article discusses energy harvesting and its applications. It explains how the process works and the challenges that designers must address to implement a fully functional solution.

What Is Energy Harvesting?

Energy harvesting uses unconventional energy sources to power circuitry. Typically, a tiny energy source is converted to electricity and stored in a durable storage cell such as a capacitor, super capacitor, or microenergy cell (MEC), which is a form of lithium solid-state battery. The system generally includes circuitry to manage the power and protect the storage device and other circuitry.

Sources of energy (**Figure 1**) include light, captured by photovoltaic cells; vibration or pressure, captured by a piezoelectric element; temperature differentials, captured by a thermoelectric generator; radio energy (RF); and even biochemically produced energy, such as cells that extract energy from blood sugar.

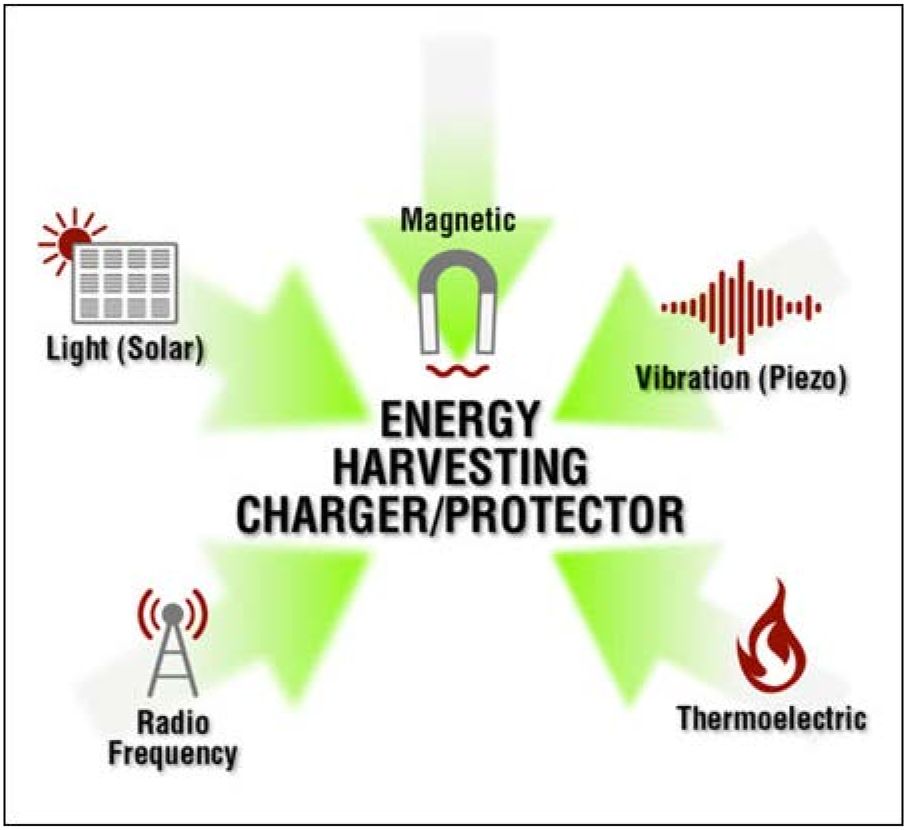

Figure 1. Energy harvesting uses unconventional sources to power circuitry.

Energy Harvesting for Remote and Portable Applications

While energy harvesting can be considered "free energy," energy cost is *not* what motivates most solutions. Modern energy harvesting is used because it eliminates the need to run expensive power cables to remote locations or the need to replace expensive primary batteries frequently. In simple terms, energy harvesting systems are more convenient and reduce costs for many applications.

There is, however, more to their appeal. Energy harvesting systems are also ResourceSmart® designs. They eliminate wasteful batteries and long powerline runs. They keep systems running without inconvenient, disruptive service calls. They enable monitoring and control at remote locations and especially in sensitive ecological settings.

Applications for energy harvesting focus on management of remote sites, systems, and mobile devices. Typical uses are control of remote sensors, remote wireless sensing devices, asset tracking and personnel identification systems for building access, and enhanced security at remote locations. Specific examples include energy supplied for remote valves for pipelines, irrigation, and other systems that include plumbing but no power; safety and control equipment that monitors oil and gas pipelines; electrically operated automatic flush toilets; wearable electronics attached to clothing or protective gear; surgically implanted electronics such as drug-delivery, monitors, and pacemakers; and smart cards, which contain circuitry but no power source. Energy harvesting is also proving useful with a variety of real-time clock (RTC)/memory backup applications and asset tracking or identification.

The Technical Challenges of Energy Harvesting

Energy harvesting solutions demand much from the electronics that support them. Consider some of these design challenges. If the energy resource is not always present, then the system needs to store energy in a battery, super capacitor, or microenergy cell. Moreover, since energy sources vary, the system must convert, regulate, and control that energy. The circuitry and the energy storage cell must all be protected from excess voltage or power spikes. The supporting electronics must be highly power efficient since the energy source is generally small.

Remote systems powered by energy harvesting must be very reliable. A service call negates any advantage of the remote control. Finally, remote systems often lack climate control or are subject to fluctuating environmental/temperature conditions. Any energy harvesting system must accommodate and operate flawlessly under those conditions.

Energy Harvesting for the Future

The Maxim MAX17710 energy-harvesting charger and protector is a new-generation power-management IC that "harvests" the energy generated from a variety of poorly regulated energy-harvesting sources (Figure 1). The MAX17710 provides the energy harvesting and power management to maximize, protect, and control the energy stored in microenergy cells such as Infinite Power Solutions THINERGY® microenergy cells (MECs) (**Figure 2**). The ultra-thin, postage-stamp-sized MECs are flexible and provide unmatched rechargeability, cycle life, and power performance. They have extremely low self-discharge rates and enable decades of shelf life. In fact, these two devices make energy harvesting practical.

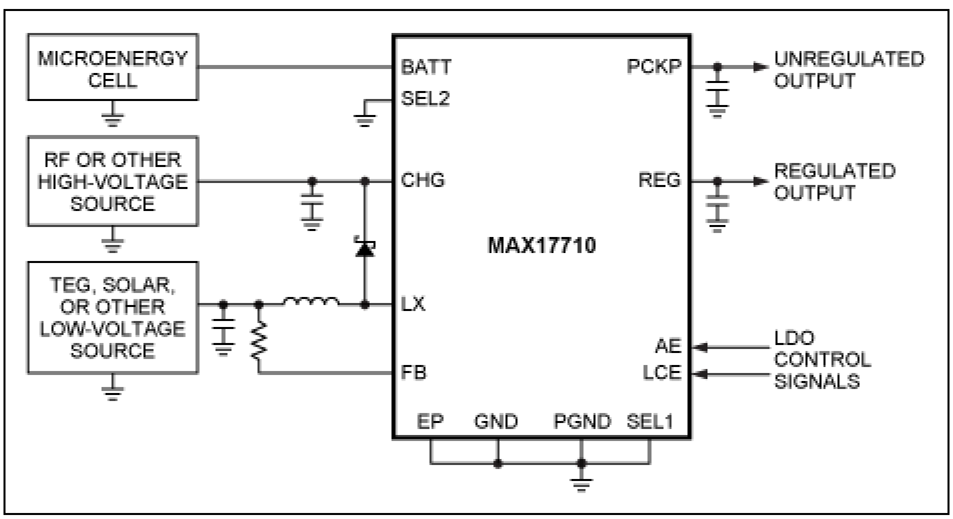

Figure 2. The MAX17710 shown in a typical application circuit harvesting from high-voltage charge sources.

The MAX17710 integrates an input boost regulator so it can boost charges from as low as 800mV. It needs no expensive external components to charge an MEC and harvests energy from 1µW to 100mW. To protect the MEC, the MAX17710 handles input source voltages higher than the MEC and regulates or shunts excess power. An ultra-low-quiescent-current, low-dropout linear regulator (LDO) with selectable voltages of 3.3V, 2.3V, or 1.8V prevents potentially damaging overdischarge of the MEC. This also allows the MAX17710 to adapt to a variety of loads, because undervoltage protection recovers only when an external energy source raises the voltage of the MEC back into a safe zone.

Temperature extremes are another concern. At very low temperatures, all batteries exhibit increased characteristic impedance which limits high pulse currents to the application loads. The MAX17710 integrates a unique feature that manages an external storage capacitor in order to provide high pulse currents.

Conclusion

Energy harvesting solutions allow electronics to operate where there is no conventional power source and without the need to run wires or make frequent visits to replace batteries. Using unconventional power sources, the energy-harvesting circuit manages the power generated and protects the energy storage device. Since the energy source is not always present, the energy harvesting system also needs to store the energy.

Energy-harvesting applications are poised to expand rapidly. Some applications are in development that will demonstrate how practical, efficient, cost-efficient, and "clean" energy harvesting is. It is clear that each new implementation with a microenergy cell is going to need some energy-harvesting charger and protection circuit like the MAX17710.

Related Parts		
MAX17710	Energy-Harvesting Charger and Protector	Free Samples

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