New Energy Harvesting ICs Power Sensors

So far various types of sensors were routinely connected by wires to their power sources. Today it is possible to install reliable, industrial-strength wireless sensors that can operate for years on a small battery, or even harvest energy from sources such as light, vibration or temperature gradients. Furthermore, it is also possible to use a combination of a rechargeable battery and multiple ambient energy sources too. Moreover, due to intrinsic safety concerns, some rechargeable batteries cannot be charged by wires but require being charged via wireless power transfer techniques. Linear Technology has introduced energy harvesting ICs designed to work with different battery voltages. **Tony Armstrong, Director Product Marketing Power Products, Linear Technology Corp., Milpitas, USA**

State-of-the-art and off-the-shelf energy harvesting technologies, for example in vibration energy harvesting from piezo transducers and indoor photovoltaic cells, can yield power levels in the order of milliwatts under typical operating conditions. While such power levels might initially appear restrictive, the operation of harvesting elements over a number of years can mean that the technologies are broadly comparable to long-life primary batteries, both in terms of energy provision and the cost per energy unit provided. Furthermore, systems incorporating energy harvesting will typically be capable of recharging after depletion, something that systems powered by primary batteries cannot do. Thus, the additional cost of adding energy harvesting to power a sensor can be offset by the maintenance cost of having to change primary batteries every 7 to 10 years, or so.

Overcoming barriers

Wireless and wired sensor systems are often found in environments rife with ambient energy, ideal for powering the sensors themselves. Today it is generally accepted that energy harvesting can significantly extend the lifetime of installed batteries, especially when power requirements are low, reducing down time in addition to long-term maintenance costs. In spite of these benefits, a number of adoption roadblocks still persist. The most significant is that ambient energy sources are often intermittent, or insufficient to power the sensor system continuously, where primary battery power sources are extremely reliable over the course of their rated life. As a consequence, some system designers may be reluctant to upgrade their systems to harvest ambient energy, especially when seamless integration is paramount.

Nevertheless, most implementations will use an ambient energy source as the primary power source, but will supplement it with a battery that can be switched in if the ambient energy source goes away or is disrupted. This battery can be either be rechargeable or not and this choice is usually driven by the end application itself. So it follows that if the end deployment allows for easy access to change a non-rechargeable battery, where maintenance personnel can readily swap it out in a cost effective manner, then this makes economic sense. However, if changing the battery is cumbersome and expensive, then the utilization of a rechargeable battery makes more economic sense.

Even if a rechargeable battery is selected, the question of the optimum method to charge it remains open. Some of the factors that will affect this decision are:

- Is there a wired power source to charge the battery
- Is there sufficient power available from the ambient energy sources to have sufficient power available to power the wireless sensor network (WSN), and also charge the battery
- Is wireless power transfer required to charge the battery due to intrinsic safety requirements due to the hazardous nature of its deployment

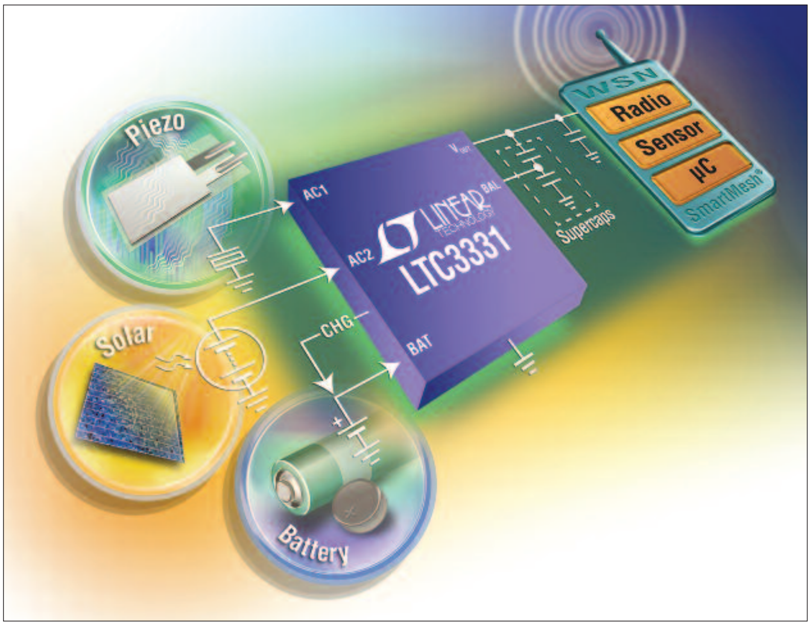

Figure 1: The LTC3331 converts multiple energy sources and can use a primary rechargeable battery

Simple IC solutions

The LTC3107 is a highly integrated DC/DC converter designed to extend the life of a primary battery in low power wireless systems by harvesting and managing surplus energy from extremely low input voltage sources such as TEGs (Thermoelectric Generators) and thermopiles.

With the LTC3107, a point-of-load energy

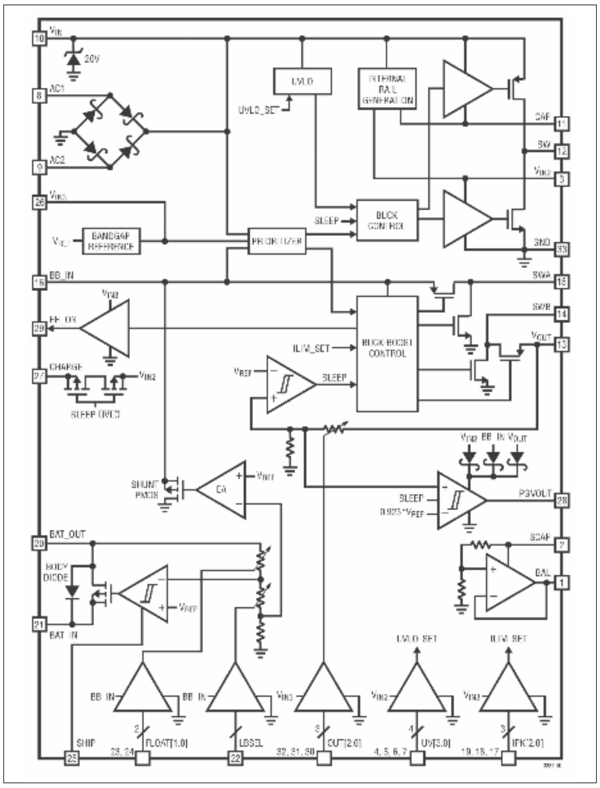

Figure 2: LTC3331 block diagram

harvester requires little space, just enough room for the IC's 3 mm × 3 mm DFN package and a few external components. By generating an output voltage that tracks that of the existing primary battery, the device can be seamlessly adopted to bring the cost-savings of free thermal energy harvesting to new and existing battery-powered designs. Along with a small source of thermal energy, the device can extend battery life, in some cases up to the shelf life of the battery, thereby reducing the recurring maintenance costs associated with battery replacement. The LTC3107 was designed to augment the battery or even supply the load entirely, depending on the load conditions and harvested energy available.

Another example is the LTC3331 (see Figure 1, 2), a complete regulating energy harvesting solution that delivers up to 50 mA of continuous output current to extend battery life when harvestable energy is available. It requires no supply current from the battery when providing regulated power to the load from harvested energy and only 950 nA operating when powered from the battery under no-load conditions. This device integrates a high-voltage energy harvesting power supply, plus a synchronous buck-boost DC/DC converter powered from a rechargeable primary cell battery to create a single non-interruptible output for energy harvesting applications such as wireless sensor nodes (WSNs) and Internet of things (IoT) devices.

The LTC3331's energy harvesting power supply, consisting of a full-wave bridge rectifier accommodating AC or DC inputs and a high efficiency synchronous buck converter, harvests energy from piezoelectric (AC), solar (DC) (see Figure 3) or magnetic (AC) sources. A 10 mA shunt enables simple charging of the battery with harvested energy while a low battery disconnect function protects the battery from deep discharge.

The rechargeable battery powers a synchronous buck-boost converter that operates from 1.8 V to 5.5 V at its input and is used when harvested energy is not available to regulate the output whether the input is above, below or equal to the output. The battery charger has a very important power management feature that cannot be overlooked when dealing with micropower sources. The IC incorporates logical control of the battery charger such that it will only charge the battery when the energy harvested supply has excess energy. Without this logical function the energy harvested source would get stuck at startup at some non-optimal operating point and not be able to power the intended application through its startup. Automatically transitions to the battery are performed when the harvesting source is no longer available. This has the added benefit of allowing the battery operated WSN to extend its operating life from 10 years to over 20 years if a suitable EH power source is available at least half of the time, and even longer if the EH source is more prevalent. A supercapacitor balancer is also integrated allowing for increased output storage. Figure 4 shows the battery charging process.

Conclusion

To facilitate the adoption of ambient energy harvesting into a wide range of new and existing primary battery-powered applications, Linear Technology has introduced energy harvesting ICs designed to work with different battery voltages. This includes most of the popular long-life primary batteries used in lower power applications, such as 3 V lithium coin cell batteries and 3.6 V lithium-thionyl chloride batteries. These products easily offer the best of both worlds – the reliability of battery power and the maintenance cost savings of energy harvesting with minimal design effort.

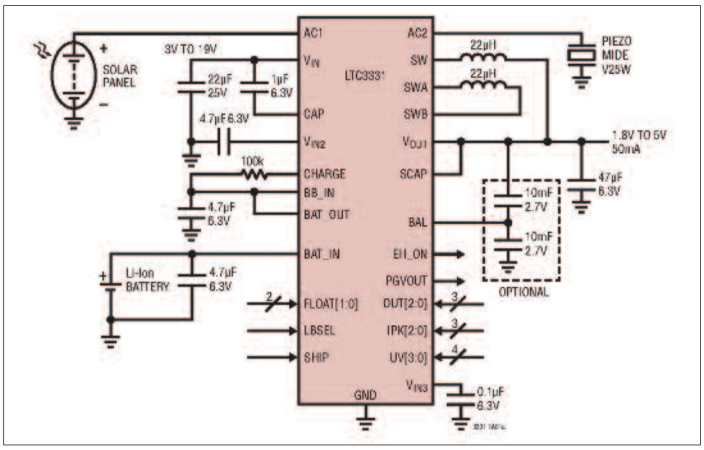

Figure 3: LTC3331 solar energy harvesting application

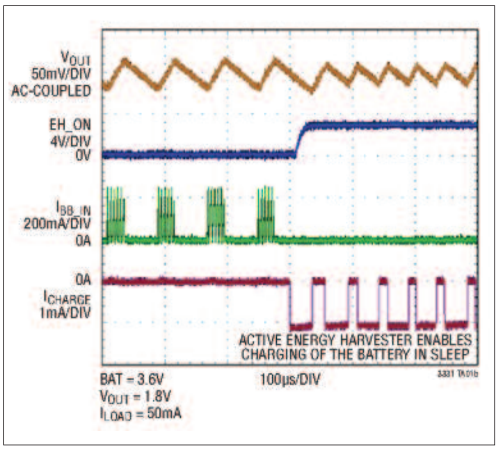

Figure 4: Battery charging process