Energy Harvesting Goes Green

Resensys

Low power and ultra low power radio frequency (RF) technologies are stimulating development of wireless sensor applications at an explosive rate. New devices are finding their way into the home, automobiles, the military, medical diagnostics, building energy management, and transportation infrastructure monitoring. This is due primarily to the availability of ultra low power-management microprocessors in energy harvesting circuits connected to sensors which spend most of their operating time asleep or in standby mode. The majority of these wireless devices are still battery-powered, but the newer designs now employ supercapacitors and eliminate the need for batteries entirely.

Interest in building automation systems and controls is also at a new high because of rising energy costs, and a growing awareness of the need to be sustainable and reduce carbons. Spending on wireless-enabled sensors in 2010 grew by more than 80% according to a market data study by ABI Research. And the potential in HVAC is even greater. Energystar.Gov estimates that there are more than 5 million commercial and industrial buildings in the US that consume $202.3 billion worth of energy annually. The combined greenhouse gas emissions of these facilities are 45% and the portion of energy in buildings used inefficiently, or unnecessarily is 30%.

Two companies that have been focusing their advanced technology on improving wireless-enabled HVAC sensor design are Resensys, LLC of College Park, Md. and Optixtal, Inc. a Delaware corporation with facilities in Pennsylvania. Together they have designed a new wireless HVAC sensor called the GreenPatch.

A Flexible Net-Zero Wireless Energy design

What makes GreenPatch unique is its size and flexibility. Weighing only 9.1 grams and having a thickness of only 1.2 - 2 mm, the sensor circuitry is mechanically flexible. The supercaps are also ultrathin and flexible; which means this wireless sensor, unlike other rigid pc board sensors, can be attached easily to contoured surfaces as well as flat surfaces. And there are no batteries, so there is no need for periodic manual intervention to check and/or replace batteries! GreenPatch is a net-zero energy-integrated wireless device that can monitor, and even turn on/off lights and HVAC to potentially save US commercial buildings about $20 billion each year - the equivalent of a greenhouse gas emissions reduction of 30 million vehicles removed from our highways.

Its small size (as small as 2" x 1.5") and low unit cost can mean more precise monitoring due to its affordability, so more devices can be installed by the user to monitor more data points. In the case of commercial office building environments, one sensor for each 200 sq. ft. of room area is the recommendation for monitoring and optimizing environmental conditions.

The ultra low power GreenPatch is capable of harvesting energy with selected transducer combinations (i.e. via vibration, motion, heat, light and RF), store it in a supercapacitor with low leakage, and then transmit signals to decrease inefficient and unnecessary energy use. On-board sensors monitor condition data such as available light, heating and/or air-conditioned room temperatures in commercial buildings. The GreenPatch collects data and reports it in a 58 byte transmission packet every six minutes to synchronize with a data collector. Communication takes 3-4 milliseconds and the transmit power is 100 mW. The effective range of transmission is 0.5 - 1.0 miles.

Testing for Net Zero Energy Use

Field Tests of an Optixtal, Inc. 1 Farad, 1.5 volt SuperXcapÔ were conducted to observe leakage current over time. In North America during winter a supercapacitor must not run out of power during an average of 14 hours of darkness. The SuperXcap lasted more than 16.5 hours with an average leakage of less than 0.9 micro amperes.

In a second test, two OptiXtal 1 Farad, 2.7 Volt SuperXcaps in series powered by three 1.8 Volt IXYS small solar cells were used with circuit protection set for 3.3 Volt cutoff to avoid overcharging. This microcircuit arrangement was then placed in a room with windows and no indoor lighting, for a period of two days. During the entire test voltage never dropped lower that 3.0 Volts during discharge. Other brands of supercapacitors tested by this means had voltages that dropped during discharge to 2.7 Volts and higher leakage current values, meaning fewer hours of operation.

Additional testing was done to calculate power and current consumption while transmitting and while asleep by applying a continuous 3.0 Volts to the sensor and observing voltage and current changes across a 4.7 Ohm resister load using an oscilloscope. The results were as follows:

Measured Power Consumption:

A.) During Transmission (each 6 minute interval): 3.12 microWatts

B.) During Sleep Time 2.10 microWatts

Total GreenPatch Power Consumption 5.22 micro Watts

Total Current Consumption =W/V = 5.22/3.0 = 1.74 micro Amperes

It was further determined that the active time of the GreenPatch sensor is only 0.002% and the sleep time is 99.998%.

Adaptable for Multi-Use, the future is now

The proliferation of ultra low power wireless sensors using minute amounts of energy to power, microcontrollers, supercapacitors and RF transceivers is making it possible for wireless networks to be powered exclusively by net zero integrated-energy harvesting techniques. In building automation wireless devices like the GreenPatch are beginning to be widely adapted by companies such as Cisco Systems, IBM, Siemens and others in a field that has traditionally been dominated by just Honeywell and Johnson Controls.

More broadly, we also see these devices embedded in helicopter rotors for mission critical military applications and in automobile speed and position sensors to control engine management. Designers are even contemplating vehicle-to-vehicle communications using these devices to improve traffic flow and control safe distances between vehicles.

Wireless already abounds in the home; in networked computers, hands-free phone communications, remote electric & gas meter reading, and soon the embedment of chips in smart home appliances to save electricity. It's also used broadly in industry to monitor processing conditions throughout plants. And, we are just beginning to see medical applications for wireless using surgical implants and endosocopic video cameras. The applications are nearly endless as wireless networks with Net Zero Energy continue to emerge and become a part of our every day lives.