Energy-Harvesting Sensor Nodes

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Project Aims

To develop and demonstrate an integrated approach to power management such that sensors within a sensor network are able to manage their energy requirements, and harvest energy from the local environment, whilst simultaneously coordinating their activities in order to achieve system-wide aggregate goals.

Energy Harvesting Technologies

Evaluation of Energy Harvesting Technology
D. Karatzas
31st March 2007

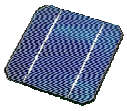
Energy Harvester	Power Generated	Notes
Perpetuum (EM Vibration)	0.05 – 5.0 mW	25 – 100mg at 99Hz
Mide (Piezo Vibration)	0.01 - 0.5mW	250 – 300mg at 37Hz
Ferro Solutions (Vibration)	0.4 – 9.3 mW	20-100mg at 21Hz
Enocean (EM Force)	0.1 – 0.2 mWs	Actuating force 2±0.5N/2mm
Tellurex (Thermoelectric)	1.5 – 5.7 W	Temperature difference: 100C
Tellurex (Thermoelectric)	40μW	Temperature difference: 5C
Schott (PV Module)	12mW / cm²	12% efficiency, full sunlight

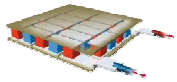
Typical power output of energy harvesting technologies.


EM Force

Piezo Vibration

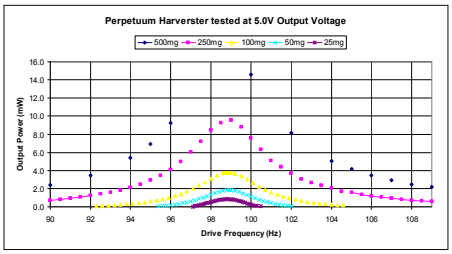

EM Vibration

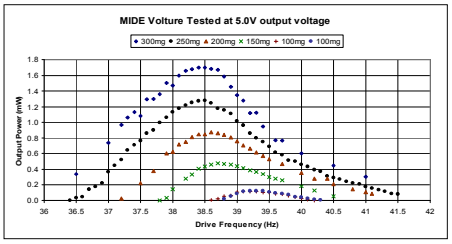

PV Module


Thermoelectric

Evaluation

Empirical evaluation of vibration harvesting technology – power output against input frequency.

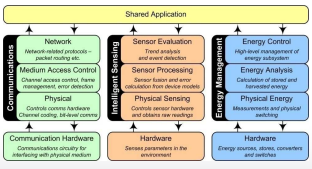




Embedded Software

Integrated approach to communication, sensing and energy management through separate stacks.

Implementing an energy-aware sensor based on the Chipcon CC2431 System on Chip.



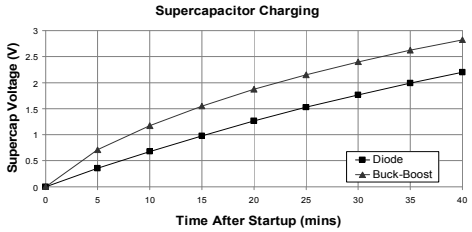
Alex Weddell, University of Southampton

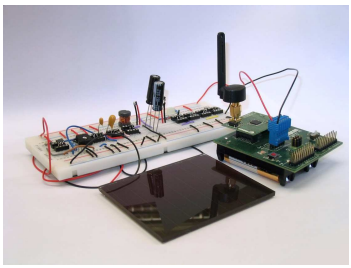
2.4GHz IEEE 802.15.4 RF Transceiver
8051 MCU Processor
8 KB RAM
128 KB programmable flash memory
Low Power Sleep Modes
Location Engine (resolution of 0.5m)
Digital battery monitor

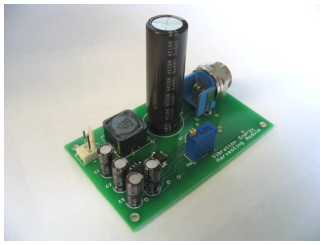
CC2431 Datasheet, Rev. 2.01, Texas Instruments, 2007

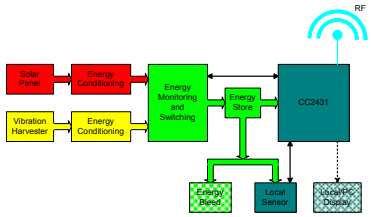
Energy Harvesting Sensor Node

Sensor node operating from energy harvested from ambient indoor office lighting using a 70cm² amorphous silicon photovoltaic module and a maximum power point circuit.




PV Energy Harvester

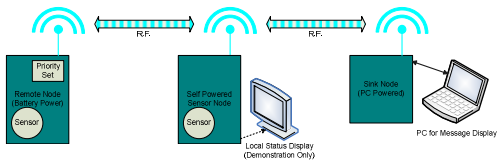

Vibration Energy Harvester Circuit



Energy Harvesting Node Architecture

Energy harvesting node is designed in a modular manner, enabling the interchange of energy harvesting technologies to suit available environmental energy. Modules incorporate electronic data sheets identifying the key parameters of the source. Demonstrated using PV and vibrational energy harvesters.

To demonstrate the energy harvesting node's capabilities it has been deployed in a simple three-node network.



Three-node network incorporating energy-harvesting node

References

1. A. S. Weddell, N. R. Harris, and N. M. White. **Alternative energy sources for sensor nodes: Rationalized design for long-term deployment**. In *Proceedings of the IEEE International Instrumentation and Measurement Technology Conference (IMTC)*, pages 1370-1375, Vancouver Island, British Columbia, Canada, 2008.
2. A. S. Weddell, N. J. Grabham, N. R. Harris, and N. M. White. **Flexible integration of alternative energy sources for autonomous sensing**. *In Proceedings of the Second Electronics System-Integration Technology Conference (ESTC)*, Greenwich, London, UK, 2008.
3. A. S. Weddell, N. R. Harris, and N. M. White. **An efficient indoor photovoltaic power harvesting system for energy-aware wireless sensor nodes.** *In Proceedings of the Twenty-Second International EUROSENSORS Conference*, Dresden, Germany, 2008.

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