Energy Harvesting Device

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Introduction

The main purpose of this project is to investigate the possibility of Energy Harvesting as an external power supply for a small electronic device. In the study the small electronic device is a serial measurement board (SMB), which is mounted in every ABB robot.

Energy Harvesting is the process by which energy available in the surrounding environment is recovered and converted into usable electrical energy, which in turn is stored and used as an external power supply. The motivation of Energy Harvesting is to completely replace conventional batteries powering those small electronic devices to instead make them self-sufficient. This would be desirable for example in tough environments like semi-active volcanoes, where sensors are placed to monitor geoseismic activity and thus replacing batteries would be hard. Another scenario where Energy Harvesting could be used is in large buildings, where thousands of sensors for monitoring temperature and humidity are spread out. Changing batteries in those sensors is costly as well as time-consuming.

An Energy Harvesting System typically consists of an Energy Source, an Energy Harvester, a power management integrated circuit (PMIC) and an Energy Storage element, as depicted in Figure 1.

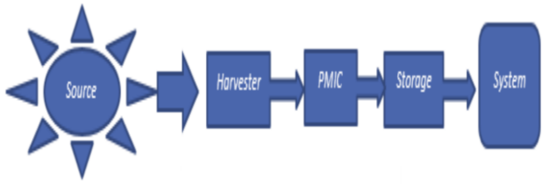

Figure 1. Typical energy harvesting system.

Potential Energy Sources can be solar-, radio frequency-, kinetic- or thermal-energy. Figure 2 gives an overview of potential Energy Sources and Energy Harvesters that converts the surrounding energy into usable electrical energy. The different Energy Sources have their own strengths and weaknesses. Solar light, for example, is unlimited during daytime and sunny days but cannot be harvested during the night.

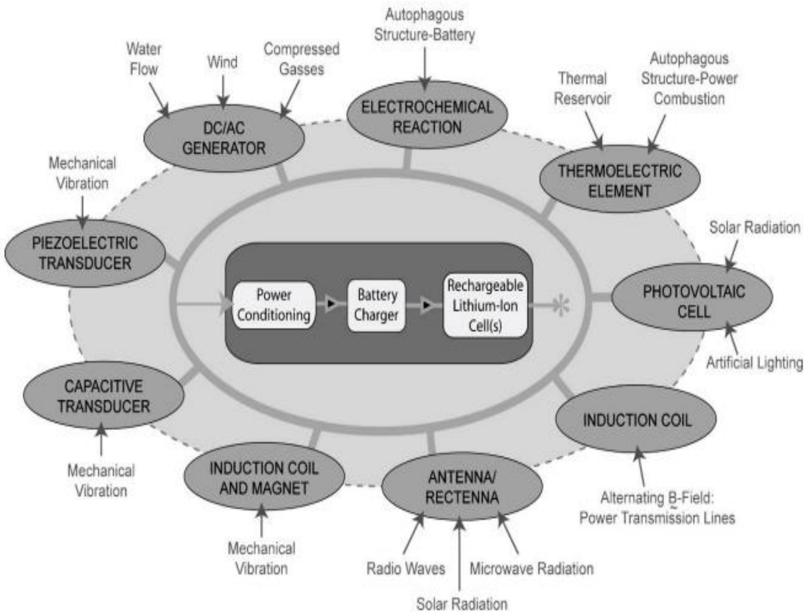

Figure 2. Different potential energy sources.

Method and Result

In this Master thesis project, the focus is put on Energy Sources that can be found in indoor environment or from a robot [1]. Due to the specification of the thesis some of the potential harvesting methods may be excluded for use. The operating mode for the harvesting method is when the robot is shut down - kinetic- and thermal-energy generated by the robot can thus be neglected. The amount of energy that can be harvested from Radio frequency is very location dependent and hard to predict, as well as the minimum generated power needed for the SMB was hard to achieve by this method. The energy harvesting method used is therefore solar and artificial light as source.

Looking back at Figure 1, an Energy Harvesting System consists of a source; as mentioned, in this project the source is artificial light, a harvester; which is a solar-panel, a PMIC; which converts an unstable, noisy, alternating input current, into a regulated direct current and transfers it to the electronic device, then we need a storage element; to store harvested energy that can be used when there is no energy to scavenge from the environment.

To know how much power a solar-panel can generate under artificial light at light intensities typical for indoor environments, measurements with light intensities of 200, 400, 600 and 1000 Lux were made. 600 Lux is the light intensity in a bright office space while 1000 Lux is typical in an industry environment.

A circuit board was built with the aim to have as small power losses as possible. To the board a PMIC with different components was soldered. The PMIC has some important features for stability and efficiency of the Energy Harvesting System, for example the PMIC can make the output voltage from the harvester to the system load constant as well as with help of software calculate the Maximum Power Point of a solar-panel, so that the efficiency of the solar-panel is maximized. Another important feature is the ability to protect the storage element from being discharged or overcharged.

As storage element, supercapacitors were chosen, this due to the expected higher numbers of charge-discharge cycles than what a rechargeable battery is designed for.

Table 1 shows generated power that could be obtained from the circuit board with a 31.8 cm^2 solar-panel connected.

Table 1. Measurements with a LED lamp as source.

Measured Lux	*Measured mW/cm^2*
600	0.0136
1000	0.0242

The SMB needs a maximum power of 1 mW to run, and as seen from Table 1, 600 Lux is sufficient if the solar-panel has an area of 74 cm^2.

To validate if the chosen method would hold for a longer time, a test for three weeks with the SMB was done. Here the solar-panel had an area of 127 cm^2, which generated a power of 1.73 mW under a light intensity of 700 Lux. According to the test results, the SMB can thus be powered from a solar-panel with a supercapacitor-bank as a backup when no harvested energy is available.

Future and Conclusion

It is already possible to take the advantage of Energy Harvesting as a method for replacing conventional batteries for small electronic devices that have low power consumption. With most of the potential energy sources there are some drawbacks, e.g. for periods of time they disappear or decrease in the area in question resulting in not enough energy being generated to power the electronics.

Solutions to make Energy Harvesting more successful is by integrating Energy Harvesting with several kinds of energy forms at the same time. This will generate more power than just harvesting from one energy source.

References

[1] Driton Salihu. Energy Harvesting Device. Master's thesis, Lund University, Division of Industrial Electrical Engineering and Automation, CODEN:LUTEDX/(TEIE-5380)/1-64(2016). [Online]. Available: http://www.iea.lth.se/publications/MS-Theses/Full%20document/5380_full_document.pdf.