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Subject Area	Wireless Communications
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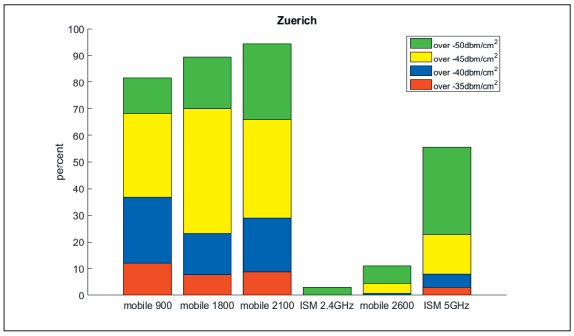
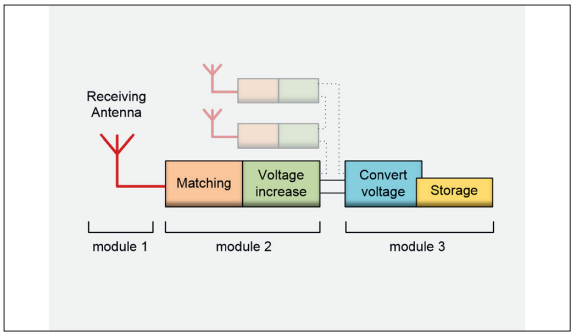
Energy Harvesting in EM Fields

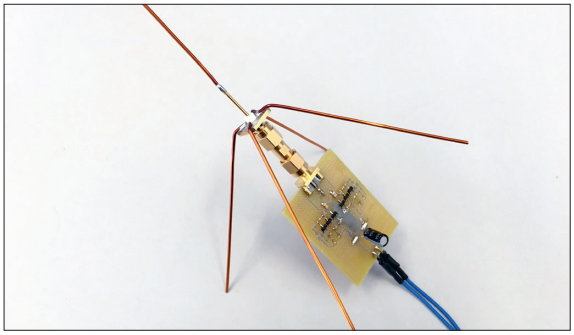
Evaluation of electromagnetic energy and design of a suitable harvesting prototype



EM power measurements in different areas to determine the best frequency band for energy harvesting



Modular design of the whole harvesting circuit



Fabricated antenna, matching circuit and voltage multiplier

The goal of this project is to evaluate the possibilities of electromagnetic (EM) energy harvesting in different environments and to build a functional prototype. The market offers more and more devices that are able to harvest energy from different sources such as light, vibration and temperature. This project intended to evaluate the potential of EM energy harvesting. Many wireless communication devices, including our personal cell phones and computers, daily radiate EM energy to exchange data. This energy, if strong enough, can be harvested and used to power low-power devices.

Proceeding: First measurements of the various frequency bands showed that the mobile phone network downlink offers the strongest signal and is widely available. The base stations transmit with relatively high power, use reasonably low frequencies and the transmitters are located in many places. The next step was to develop a suitable harvester. A modular construction allowed easy modifications and testing. The biggest challenge was to build a good matching circuit. First prototypes were matched on a very narrow band and could not deliver enough voltage at the output. The later prototypes were built differently to allow an easier matching circuit with lumped elements. Another problem was the low output voltage at the multiplier circuit. To overcome this problem, several electrically insulated energy harvesters were connected in series. This configuration provides a suitable voltage for the DC/DC converter. Another advantage of connecting insulated harvesters serially is that energy from various sources and frequencies can be harvested simultaneously.

Result: Through measurements in various places, the average and peak signal strength of the mobile network could be determined. The downlink frequency band was found suitable for energy harvesting in many environments. However, there are still many locations which have an overall signal strength which is below the limit of current energy harvesting systems. With the above described energy harvesting setup, it was possible to achieve better results than the reference harvesting circuit. Overall, energy could be harvested down to –53 dBm/cm^2. That is equivalent to an input power of –33 dBm at each harvester. The average voltage was around 100 mV at the output of the harvesting setup. This power is enough to operate a small DC/DC converter and then a microcontroller, sensors and other devices wirelessly and without any other source of power.