Multiband Radio Frequency Energy Harvester

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Introduction & Motivation

Wireless Electromagnetic energy is widely available in urban areas at power levels between -40dBm/m^2 (100nW/m^2) and -10dBm/m^2 (100μW/m^2). At the same time, the required digital energy per switch for 65nm CMOS technology is only 0.08fW. It is very promising to harvest ambient radio frequency (RF) energy and use it as a power source.

The energy strongly exists in different bands such as 890MHz, 1800MHz. In this poster, a multi-band RF energy harvester is presented. The energy harvester can generate more than 1V for an input RF power as low as -19dBm at two different frequency bands 890MHz and 1800MHz. Moreover, this work can be to extended into multi-band energy harvesting.

Applications

- Wireless bio-medical applications to remove the long wires from medical devices.
- To extend RFID tag range.
- To remove or reduce battery requirements on mobile devices such as wireless sensor networks.

Harvester Circuit Diagram

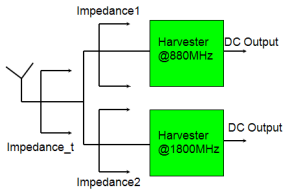

Fig. 1. The structure of the dual band energy harvester.

- Due to the weak available signal, each harvester is required to achieve low impedance on its harvesting frequency while achieving high impedance at other frequencies
- Requirement
  - Impedance_t
    - 50Ohms@890MHz
    - 14Ohms@1.8GHz
  - Impedance_1
    - 50Ohms@890MHz
    - 1000Ohms@1.8GHz
  - Impedance_2
    - 1000Ohms@890MHz
    - 14Ohms@1.8GHz

Energy Harvester Circuit Design

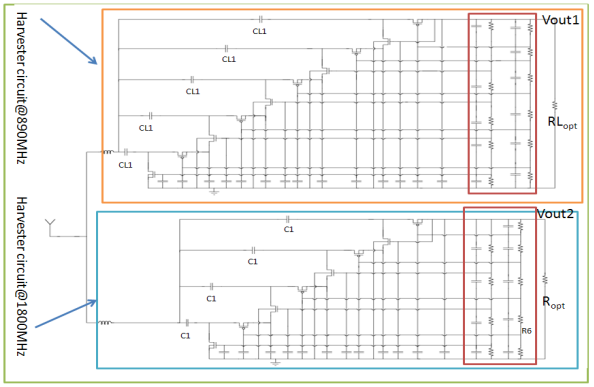

Fig 2. a) Circuit schematics of the dual band energy harvester.

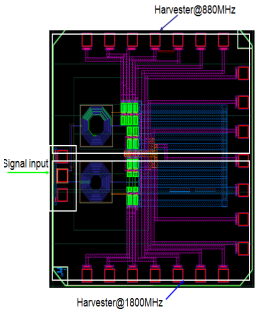

Fig. 2 d) Chip layout of the dual band energy harvester.

- C1s, CL1s are AC decouple-couple capacitors.
- All the capacitors and resistors in the orange box are used for a DC self-bias purpose.
- R_{opt} , RL_{opt} are optimized to achieve the maximum output power efficiency.
- All remaining capacitors are bypass to work as ac short and dc block.
- The NMOS/PMOS connected diodes work in a similar way as regular pn diodes.
- Vout1 and Vout2 are the DC outputs.
- RF_{in} is the AC input.

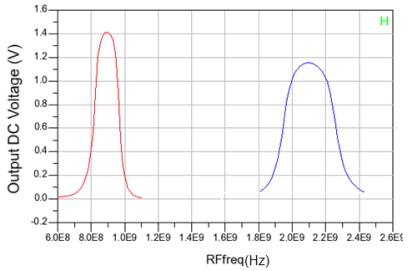

Fig. 2 b) Simulated DC output voltage at different frequency bands (the input power is -19dBm).

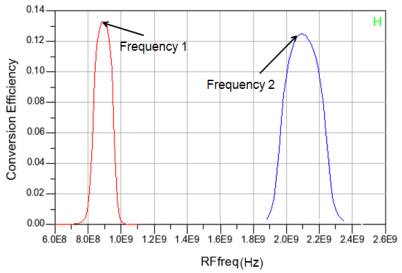

Fig. 2 c) Simulated energy harvester AC to DC conversion efficiency at different frequencies (the input power is -19dBm).

Dual-Band Antenna

Fig. 3 a) Fabricated printed circuit board antenna.

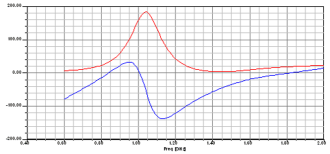

Fig. 3 b) Simulated antenna impedance at different frequencies. (The antenna has an impedance of 45 ohms at 890MHz while achieves 18ohms at 1800MHz.)

Achievements

- The energy harvester can generate more than 1V DC voltage for an input power as low as -19dBm which is close to ambient RF energy from mobile or TV towers.
- The generated energy is enough to power the current digital devices, which presents promising battery-free mobile electronics.
- The energy harvesters can provide power from different frequency bands.
- The conversion efficiency can be as high as 14.4% for -19 dBm input power. The conversion efficiency increases as input power increases.
- No external power source is required.

Intellectual Merit
New paradigm for energy harvesting.

Broader Impact
Benefits to society: Clean energy, improved electronics